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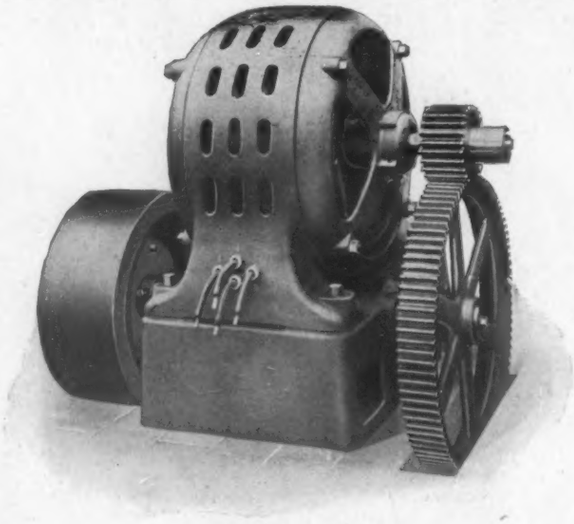

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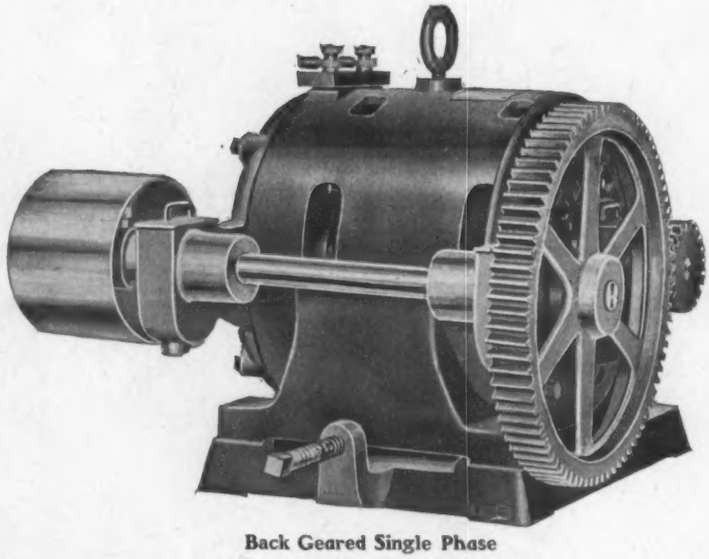

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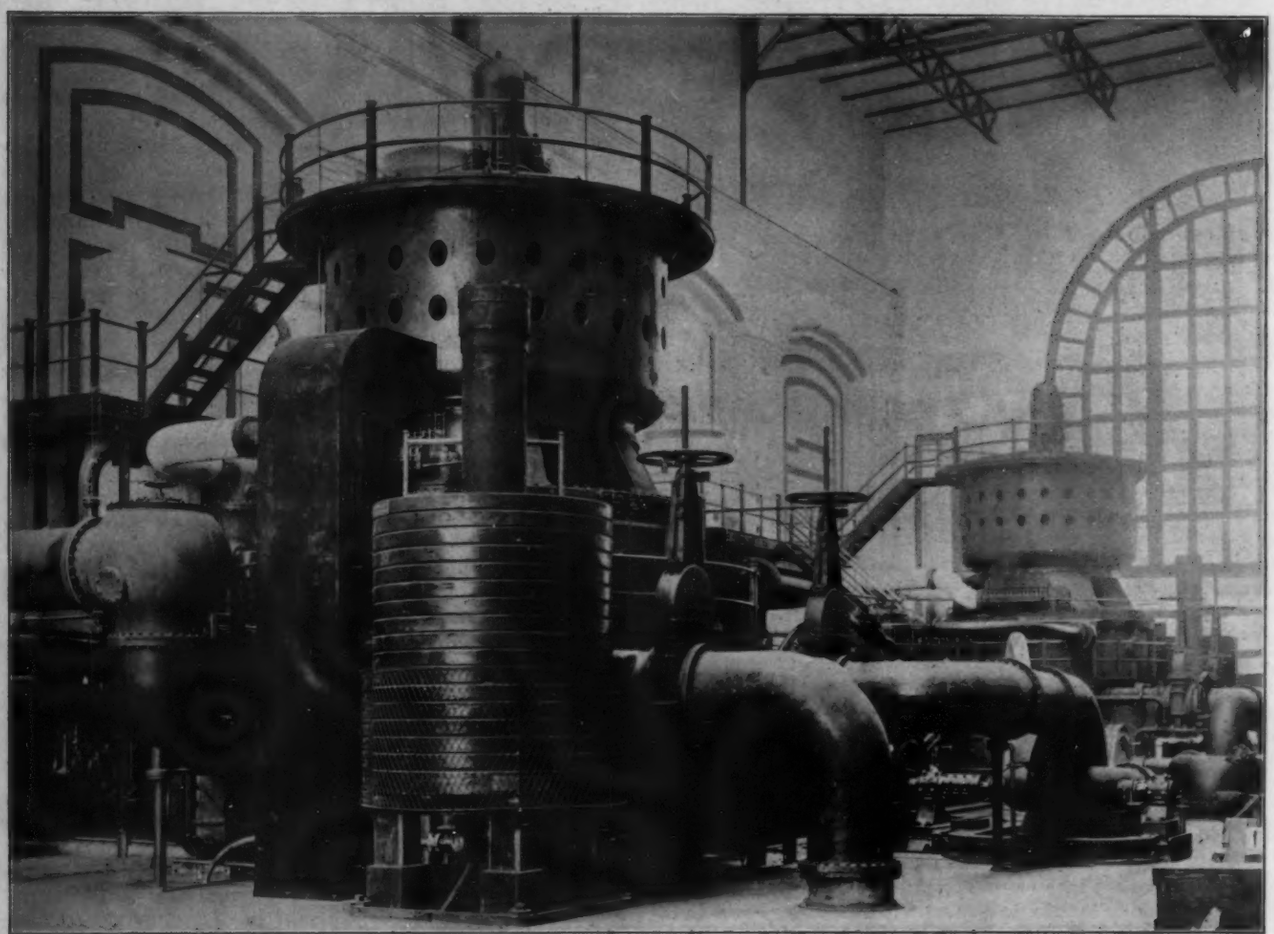
VOLUME XVIII. SAN FRANCISCO, CAL., MARCH 23, 1907 No. 12

The Boston Steam Turbine Electric Station.

One of the most thoroughly up-to-date and interesting central stations in the United States is that of the Edison Electric Illuminating Company, of Boston, Mass., equipped with four stage Curtis steam turbines, as shown in the accompanying illustrations.

The steam turbine station is located adjoining the old plant which is equipped with reciprocating engines of the compound type, the latter having been installed by the Boston Electric Light Co. several years ago. The old plant includes a half-dozen units of 1,500-kilowatts each, vertical compound engines of the McIntosh & Seymour type, being directly coupled to electrical generators of a combined capacity of about 9,000 kilowatts, while the total output of this plant could easily be carried by the two Curtis turbo-alternators noted in the accompanying views of the turbine plant equipped by the General Electric Company, of Schenectady, N. Y.

Each of the 5,000 kilowatt units consists of a four-stage Curtis steam turbine operating at a speed of 514 revolutions per minute and directly coupled to a General Electric three-phase alternator supplying a current of 6,600 volts pressure and a frequency of 60 periods per second. The turbines are mounted upon especially designed surface condensers which form the base of the turbine structure as noted in the accompanying illustrations.



5,000-KILOWATT CURTIS TURBINES DIRECT CONNECTED TO 6,600-VOLT GENERATOR.

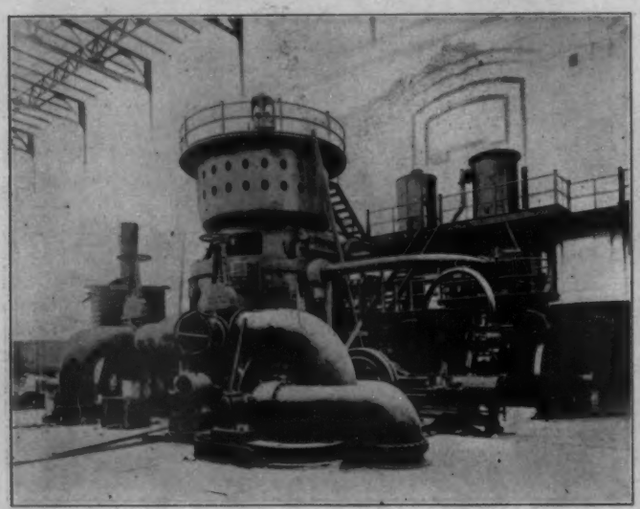
The revolving field of the alternator mounted on the top and forming the upper portion of this 5,000 kilowatt unit is nearly nine feet in diameter and weighs nearly 35 tons, the

total weight of the turbo-alternator without the condenser being 230,000 lbs. It is stated that the total weight of each unit is 260 tons, which is about 4,000 lbs. or two tons per square foot of base.

The turbine station of the Boston-Edison Illuminating Co. was designed for a dozen units of 5,000 kilowatts each, or a total output of 60,000 kilowatts, while the turbo-alternators installed have a maximum overload capacity of 50 per cent for two hours without danger, so that the total peak load capacity of the station is nearly 100,000 kilowatts when fully completed.

Each of the Curtis four-stage turbines has 15 sets of initial nozzles on each side, with three rotating discs, each carrying two sets of blades, the turbine wheels each having a diameter of about 13 feet. To each of the nozzle chests of the turbines is connected a 10-inch pipe connecting with a 15-inch steam main and no exhaust pipe is necessary, as the turbine is mounted directly upon the condenser, as mentioned above, and there is an automatic release valve arranged for discharging into a free exhaust main two and a half feet in diameter.

The turbine station is constructed on the unit plan, each pair of turbines being supplied with steam from its own bank of boilers arranged in four batteries of two boilers each of 513 horsepower capacity for each turbine unit, as well as the necessary condensing and other auxiliary machinery required. The boilers each have a heating surface of 5,118



ANOTHER VIEW OF 5,000-KILOWATT CURTIS TURBINE.

square feet with a grate area of 110 square feet, measured on the inclined plane of the Roney stokers and a superheating surface of 867 square feet. These boilers have tubes 18 feet long, 14 tubes high and 18 tubes wide, and the steam pressure carried is 175 pounds per square inch with steam superheated by 150 degrees.

The total length of the boiler house and turbine room is to be, when completed, 640 feet, the boiler house being 150 feet wide, and the turbine room nearly 70 feet in width. Each pair of turbines forming a group, with its boilers and auxiliary equipment is provided with a separate chimney, there being six chimneys designed for the completed station of 90,000 horsepower capacity.

The coal is brought by boat to the wharf at the power station, which is provided with two towers, equipped with buckets of one and one and one-half tons respectively, delivering the fuel to a belt conveyor which conveys it to a bridge 60 feet high, with a span of 155 feet and 82 feet cantilever. This allows a distribution of the fuel with ground storage of 140,000,000 lbs. of coal, 40,000,000 lbs. being under the trestle, with a bunker capacity of 1,000,000 lbs. near the old plant.

A two-ton bucket is used on the bridge delivering the coal to conveyors serving the boilers, these conveyors being also loaded when desired. An individual coal hopper is arranged for each boiler capable of holding 88,000 pounds of fuel or sufficient for nearly two days' operation with 20 pounds per square foot of grate. The accumulator is six feet nine inches in diameter outside of weights, which may be noted in the illustrations, together with the circulating water pump, vacuum air pump and other auxiliary apparatus.

COPPER MARKET SITUATION.

"The situation as regards the copper market shows a tendency to continued firmness, and there is no semblance at this writing of an immediate change in the character of the market," quotes "Copper Gossip," a publication published by the National Conduit & Cable Co. "There has been very little fluctuation in local quotations for a considerable time, and new business for several weeks did not figure up to the heavy transactions we were accustomed to hear of a few months ago. A fresh buying movement was started recently, however, which resulted in producers disposing of large quantities of copper for future deliveries. Latest sales include deliveries up to May and June. The market for distant futures now quotes 25¼ and 25½ for electrolytic wire bars, with lake as high as 26c for the best brands.

"If we are able to rightly gauge conditions we believe consumers of copper, to an extent more or less annoying, are compelled to operate their plants under disadvantages because of the inability to procure copper up to the level of their requirements during the next two or three months. There is no question but that some of the leading consuming interests deem it inconsistent with conservative methods and strictly sound business principles to run short-handed for the next ninety days, and at the same time jump into the market and load themselves up with copper at present prices, for which they cannot obtain delivery before the months of May, June and July. What the level-headed manufacturer specially wants is copper now wherewith he can fill his orders in February, March and April, and when April comes round he will be fully prepared to negotiate for his May, June and July copper on the market basis then current.

"Consumers of copper are in the position where they want to be reassured to a tolerably definite extent that everything possible will be done to prevent a scantiness in the supplies of raw material. This is necessary for the promotion of good and satisfactory business conditions. The present remarkable success of the entire copper mining industry is owing to the enormous demand for the product of the companies furnishing the metal, and every consumer is contributing his quota to the marvelous prosperity of the copper companies. We disclaim most positively any disposition whatsoever to make any rash or unmerited criticism on the methods of producing interests or to dictate what their policy should be, but we do believe the importance and magnitude of the establishments melting down copper in this country is such that they may rightly claim every reasonable consideration from those who have it in their power to adjust matters to prevailing conditions, so that the least possible hardship or injury will be done to the great and influential body of manufacturers dependent upon copper for from 75 to 90 per cent of their raw material."

Vancouver, B. C.—Prince Rupert, the Pacific terminus of the Grand Trunk Pacific, is soon to be connected with this city by wire. A. D. Smith will install telephone wires between all camps in the vicinity of the terminal points. They will also make connection with the Yukon telegraphs at Aberdeen.

SWITCHBOARDS.*

J. D. Ross.

In designing a switchboard for a large generating plant or substation, four things are to be sought for—safety of human life, reliability, flexibility, and simplicity. To secure safety and continuity of service the high voltage bus bars and switches should be in duplicate as far as possible, so that one set may be cut out for changes or repairs without interrupting service or requiring employees to work on live wires or apparatus. In all alternating work no dangerous voltage should be carried to any apparatus on the switchboard. All measuring instruments can be operated from series and potential transformers, while all switches or regulators of any kind can be operated by a remote control system. In this we are given a choice of three systems: Mechanical control, closed circuit electric control and open circuit electric control.

Mechanical control by means of rods and bell cranks or sprocket wheels has the advantage of being simple and reliable. Its main objection lies in its clumsiness and to reduce this to a minimum we must mass all switches and regulating devices close together to shorten the operating gear. The "closed circuit control" of switches by means of a closed circuit pilot system seems to have no excuse for existence until more reliable switches are designed. The "open circuit control" of switches by means of an open circuit pilot system is reliable and simple whether operated by solenoids or motors. The solenoid type is apparently the better at the present time.

In either system the main switch should follow the movements of the pilot switch on the board so that the operator may know by its position whether the main switch is in or out. Pilot lamps in addition operated from the main switch and placed beside the pilot switch make the system more complete.

Having now only electric connection between switchboard and apparatus we may allow more room for apparatus, lessening the chance of damage from short circuiting and allowing greater convenience for repairs. On the other hand the switchboard being free from heavy switch handlers and large cables may be very much reduced in size.

To make the switchboard still more compact all instruments, such as integrating wattmeters and curve tracing meters not required for actual operating, may be placed in another convenient location. All wires of dangerous voltage should be supported on angle iron rack work well grounded. By this means if the plant is designed so that working on live wires is necessary, there is no possibility of accident except by actual contact of a wire. All low voltage wires should also be on iron rackwork to avoid danger from fire.

After considering the above points I have designed several switchboards for various purposes. One is being installed at present for the distribution of alternating current at 2,400 volts for lighting and power. A description of this will best illustrate the points I wish to emphasize.

The feeder panel is 10 inches wide and 90 inches high.

Beginning at the top it is equipped as follows: One pilot lamp, one ammeter, one 6-point voltmeter plug, one Bristol Recording Voltmeter, one regulator push button, two pilot switches, one for each set of bus bars, four switch pilot lamps, one contact making voltmeter, two overload relays placed on sub base of panel A potential transformer is placed at the center of distribution and connected with the station through a pressure wire. The drop of voltage in this wire is compensated for in a small auto transformer and leads from this connect to the Bristol meter, the contact making voltmeter and one side of the six-point voltmeter receptacle. The other side of this receptacle is connected to a second instrument transformer in the station on the same circuit to take voltage readings in emergency if the pressure wire should break.

The contact making voltmeter raises or lowers the voltage automatically by controlling the regulator through a pilot system. As it and the Bristol meter are both connected to the pressure wire it is evident that the Bristol chart will be nearly a perfect circle if the inertia of the regulator is not too great for rapid motion.

A second winding from a series transformer in the circuit is placed on the contact making voltmeter to compensate for the drop in voltage due to C R losses. This is switched on with a double throw switch as an alternative in case of a breakage of the pressure wire. This makes practically a compensating voltmeter and where the power factor of the circuit is nearly unity, this arrangement will be almost as satisfactory as the pressure wire system.

The regulators are controlled by two clutches driven continuously in opposite directions from a shaft running the length of the rack work. The clutches are operated electrically by the contact making voltmeter. The shaft is operated from two small motors, one on either end. The two motors are connected one to each set of bus bars so that if one set is out, the shaft will still revolve. If both sets of bus bars are dead, due to accident, there is no need for the shaft for regulation.

We are arranging switches to be closed by this shaft by a magnetic clutch and to be held in place by a catch. The opening is done by a solenoid operating on the catch, both clutch and solenoid being controlled by the pilot switch on the board. This system is not carried out on the main switches, a closing and opening solenoid being used.

Overload relays are used on the circuits to close a contact in multiple with the pilot switch, used to open the feeder switch. All switches have their terminals connected under the oil, thus avoiding bare terminals and lessening the danger.

Each switch and regulator is in a compartment by itself and is separated at sides and back from its neighbor by barriers of sheet iron. Immediately above each is a small marble panel with flat stab switches so arranged that any oil switch or regulator may be cut out and removed at any time without interrupting the service. All wires are rubber and asbestos covered, and the bus bars are given a liberal insulation of empire cloth or linen tape boiled in paraffine to drive out the water and drained dry, the whole being then made fireproof by a taping of asbestos soaked in sodium silicate. Much of this work is done in our own shop.

I have not touched on direct current work, as that has been taken up in previous lectures under "Electric Traction," but have only attempted to outline some of the principles that should be studied to give the most successful operation of alternating current.

*Second lecture of Mr. J. D. Ross, to students in Electrical Engineering, University of Washington.

HIGH STEAM PRESSURE WITH MULTIPLE CYLINDER ENGINES.

Ten years ago there was much discussion among English mill engine builders as to the extent to which steam pressure might be advantageously raised with the consequent adoption of multiple cylinders. A number of triple and a few quadruple engines were put down, but for the last seven or eight years there has prevailed an increasing tendency toward compound engines working at 150 to 160 pounds, even for 1,800 and 2,000 horsepower capacities, as experience has shown that, while they have great advantages in point of simplicity and reliability, they can compete very closely in thermal efficiency, being actually the least expensive and most satisfactory type of engine to use.

LARGE GAS POWER PLANTS.*

C. E. Douglas.

The three principal prime movers available in this country for powers of 200 b. horsepower and over are the reciprocating steam engine, the gas engine, and the steam turbine. With the increasing adoption of electrical driving for the majority of industries, the low-speed steam engine is gradually being displaced, and, on the other hand, the scope of its high-speed rival is limited by the universal adoption of the steam turbine, especially for outputs of 1,500 b. horsepower and over. The author is of the opinion that even the most sanguine of gas engine builders prefers to limit the maximum size of his unit to somewhere in the neighborhood of this output, viz., 1,500 b. horsepower, although larger units are in operation. Except in the case of large power supply companies, city corporations, and a few isolated instances of large manufacturing works, the ordinary industrial unit ranges from, say, 200 to 1,500 b. horsepower, and therefore it is with the suitability or otherwise of gas plant for such installations that this paper deals.

The most weighty consideration which determines the adoption of one or other form of prime mover is reliability, combined with low cost of operation. No one dreams of questioning the reliability of the reciprocating steam engine; but is the cost of operation a minimum? There is an impression abroad that steam turbines are not so reliable as reciprocating steam engines. This impression may be unfounded, but the cost of turbine operation, in medium powers at any rate, is not less than that of high-class steam engines. What prime mover, therefore, is available to give power at a lower cost of operation? The gas engine is the only one which meets this demand. The critic will at once raise the question of reliability, but the author will endeavor to prove that, for industrial purposes, the gas engine, along with its supply plant, is at least sufficiently reliable to warrant a much extended sphere of operation, and that it can be operated with greater economy than any other form of power plant, at least within the limits stated.

It is an unfortunate but incontrovertible fact that the majority of power producers and users in this country are of opinion that the large gas engine is still in an experimental stage. The fact—and fact it is—that on the Continent large gas engines aggregating literally hundreds of thousands of horsepower are installed and in constant daily use, seems to leave the majority of British power users unmoved. It is perfectly true that a large majority of big gas engines on the Continent are working on waste gases from blast furnaces, but this is simply a matter of local conditions and convenience, and there is neither reason in nor proof of the assumption that a large engine is more reliable working with blast furnace gas than with producer gas. It is true that there is often considerable difference between these gases as to chemical and physical constitution, and blast furnaces gas is usually weaker than average producer gas in the proportion of, say, 90 to 145 b.t.u. per cubic foot. On the other hand, there have been working in this country for long periods engines of several hundred horsepower in one unit on waste gases from coke ovens, where the calorific value is often over 400 b.t.u. per cubic foot, and engines of 1,500 b. horsepower are being installed at the present time to work on such gas. The London County Council are installing several large engines of about 250 b. horsepower to work on town's gas having a probable value of 500 to 600 b.t.u., and in America there are instances of large engines running for long periods on natural gas, having a value of 1,000 b.t.u. per cubic foot.

Citing these cases shows that the value of the gas has nothing whatever to do with the satisfactory operation of the engine, provided, of course, that the value in any installation remains reasonably constant, that the engine is designed to suit the gas, and that the gas is suitably cleaned before admission to the engine. If successful and far-seeing firms like Krupp, who had one gas power station of some 12,000 b. horsepower in constant operation, decided only a year ago to instal two further units each of 1,600 b. horsepower, and like the Gutehoffnungshutte, who have year by year increased their gas engine plant to some 10,000 b. horsepower capacity; and if other large manufacturing concerns have done likewise, surely the case for the reliability of the gas engine is proved. If it is reliable abroad, what conditions either of manufacture, installation, or operation militate against its success at home? There is no question but that large gas engine builders have now learned in many cases through sad experience; but if experience is a hard master, the lesson may be well learnt with profit both to the builder and to the user. This state has been attained, and the installation of large gas engines and plant has definitely passed out of the experimental into the commercially profitable stage; there are numerous and authentic cases of large gas engines operating night and day continuously over long periods, with absolutely the same degree of steadiness and reliability as a steam engine.

Turning to the question of economy of operation, it is not sufficient to consider merely the usual station or working costs; we must also take into account interest and depreciation on capital outlay, because in most cases of large gas power plant this is somewhat greater than the outlay involved by a new steam station of equal capacity.

It is, perhaps, difficult to make a direct hypothetical comparison, because conditions vary so much and are so largely influenced by locality, but the author is confirmed in the belief that in spite of higher capital outlay the total generating costs, including interest and depreciation work, out in most cases distinctly in favor of the gas station.

Taking works costs alone, and assuming that we have proved the reliability of the gas plant, the items for wages, running stores, repairs, and maintenance differ little in the two cases, on the other hand even the most inveterate critic of the gas engine cannot deny its marked superiority as a heat engine over the steam engine. This means a substantial diminution of the heaviest item in works costs, i. e., the fuel bill. There is a further saving in that the stand-by losses in the case of gas are really very much less than in the case of steam; this has been proved over and over again. A gas producer only requires about one-twentieth of the fuel that is necessary in the steam boiler for banking fires overnight or during periods of light load. Mr. Dowson, in his recent book on "Producer Gas," has shown that on a 500 b. horsepower steam plant the stand-by losses have been assessed at 15 per cent. of the total fuel consumed in twenty-four hours, while the stand-by losses in a gas plant of equal capacity only amounted to 2 per cent. of the total coal consumed. These figures are substantiated by numerous other tests. In the case of municipal stations with a relatively low load factor, this point is of the utmost importance. Instead of having the continual and serious loss due to the condensation of steam in pipe ranges, we have the beneficial cooling of gas tending to increased efficiency and cleanliness. It is frequently stated that the heat efficiency of the gas engine on low loads is bad compared with the heat efficiency of the steam engine under similar loads. The curves shown in Fig. 1 give the comparison between the two, the figures in each case being based on actual results and not on assumption. We have therefore two factors making for economy with gas, first the actually lower fuel consumption per unit generated on continuous load (whether full or otherwise), and the substantial reduction in stand-by losses.

The table shown gives the published working cost of ten large municipal stations, and a diagram has been made from the averages of these showing that fuel alone amounts to half the total working costs. It is precisely this item which can be so substantially reduced with gas plant.

*Abstract of paper read Jan. 22, 1907, before the Manchester Section of the I. E. E.

Name of Borough.	Type of Engines.	No. of Units sold per annum.	Cost in Pence per Unit Sold.					Load Factor. Unitsx100. Max. L.xHrs.
			Coal and other Fuel.	Oil, Waste, and Stores.	Wages.	Repairs and Maintenance	Total Works Cost.	
Liverpool	Reciprocating	31,452,323	.27	.04	.11	.08	.50	22.7
Bradford	"	13,733,651	.23	.04	.07	.27	.61	24.5
Edinburgh	"	12,914,119	.28	.04	.06	.16	.54	16.8
Leeds	"	9,197,259	.18	.02	.09	.19	.48	15.6
Bolton	"	6,055,551	.26	.04	.10	.11	.51	21.4
Blackburn	"	3,331,460	.30	.08	.17	.09	.64	16.75
Coventry	"	2,522,100	.27	.02	.13	.16	.58	18.7
Bootle	"	2,292,974	.25	.03	.15	.14	.57	21.25
Dudley	"	1,611,500	.37	.08	.10	.08	.63	13.5
Govan	"	1,602,606	.24	.05	.16	.12	.57	16.4
		Average..	0.265	0.044	0.114	0.140	.56	

Average works cost per unit sold in electricity works (lighting load).

As to capital cost, a close examination of completed and carefully projected installations generally shows that if a new steam station is to be installed on the most economical lines, and is equipped with coal handling plant, economisers, feed heaters, superheaters, possibly water purification plant, oil separators, and surface condensers, the total cost of the installation, including buildings, foundations, and chimney, is not far short of the cost of installing gas. It is not necessary to provide a house for the gas producing and cleaning plant, except in so far as it may be necessary to erect a corrugated iron screen or roof to shelter the men when they have to work on top of the producers. In the evidence before the Royal Commission on Coal Supplies, it was stated that the complete large power gas installation might cost some 10 per cent. more than a complete and highly efficient steam plant of equal capacity; this estimate was based on actual installation figures. As a matter of fact the author has authentic figures from which it appears that the total cost of some gas engine installations is actually less than that of steam plant, each complete in every respect.

While gas plant can be installed to drive electrically or direct, in most cases it will be obvious that locality and existing conditions govern to a large extent a decision as to the installation. For large powers it is only in rare cases of special convenience—and generally these are municipal—that town's gas can be used, on account of the relatively high cost of the same compared with producer gas; the former would require to be delivered to the consumer at a figure well below 1s per 1,000 cubic feet, to compare with the cost of the latter.

We, in the British Isles, are the fortunate possessors of large supplies of excellent coal for power gas purposes; and whether that coal be anthracite or bituminous (provided that, if the latter, is be a non-caking variety) there are now many excellent producers, or generators, as they are sometimes called, which will efficiently gasify such coal. In Scotland and in the North and Midlands of England, many non-caking coals are available; and as far as calorific value is concerned, the resultant gas is reasonably uniform, ranging, under certain conditions of operation, from 130 to 170 b.t.u. per cubic foot, by calorimeter. Some of the coals are exceedingly soft, with the result that much tar is produced and extra cleaning plant must be installed to cope with it. Caking or coking coal is inadmissible, because, though its gas-producing qualities may be as good as those of non-caking coal, it is physically impossible to work it, as the coal forms a sticky mass which chokes the producer. Coke is also, in many cases, applicable for producer purposes; but modern gas-works coke is often insufficiently carbonised, with the result that as much tar is produced as though soft bituminous coal were used. Anthracite is an ideal fuel to use; but excepting where it can be obtained in reasonable proximity to the site of the plant, as, for instancee, in the South and Southwest of England and Wales, its cost generally precludes its use, except for small plant. The amount of tar produced and consequently the extent and cost of the gas-purifying plant required, is a minimum.

On the Continent and also in America, briquettes, lignite, peat, wood, and charcoal are all employed successfully; and in most of our Colonies as well as in the far continents, coal suitable for producer purposes is now being worked. Regarding the producers themselves, these are classified according to whether the air and steam required for the formation of the gas are drawn through the bed of the fuel by the action of the engine, or whether they are forced through by an independent blower; thus we get the suction and the pressure producer respectively.

It will be seen that the coal supply available is practically the first consideration; and that the higher the price of coal the greater the saving to be effected by gas. In one works near London the proprietors of a mill burned anthracite (costing about 20s. per ton) under their boilers, in order to prevent smoke nuisance in a densely-populated district; they installed a gas engine of 500 b. horsepower to replace their steam engine, and a producer plant to gasify bituminous coal was put in. In this case, in addition to, let us say, at least halving the amount of coal formerly used by the steam plant, the price of the coal per ton was practically halved as well, so that the original fuel bill is now reduced by about 75 per cent.

Another point which is of great importance is the question of water supply. The water consumption of gas is much below that of steam plant; taking irrecoverable water alone—i. e., that used for raising steam—in the first place to generate gas, and in the second to supply steam engines, about one and a half pounds of steam are required per horsepower-hour with gas engines, while we can safely take 15 pounds of steam per horsepower-hour as being required for condensing steam engines. For auxiliary purposes the amount of water required varies in both cases. In a paper read before the Institution of Engineers and Shipbuilders in Scotland on the 20th of November last year, Mr. Hugh Campbell stated that for suction gas installations, the total quantity of water required, both for raising steam and purifying gas, is from one and a half to two gallons per b. horsepower-hour. This statement evoked lively criticism, but one firm of producer makers gives a figure of only 600 gallons per hour for a 1,500 b. horsepower producer; another firm works on the assumption that six gallons of water per b. horsepower-hour are sufficient for all producer purposes. In addition to the water for the producer, water is required for the engine jackets. Some makers do not water-jacket the pis-

tons of lower-power engines; but assuming these to be water-cooled, let us allow that 12 to 15 gallons per b. horsepower-hour is sufficient for all engine and producer purposes. For condensing purposes in this country, an average figure for circulating or injection water is 35 times the weight of steam condensed, in the case of the steam plant, therefore, 52.5 gallons are required as against a maximum of 15 gallons for the gas plant, and taking the irrecoverable water as well, we get a ratio of 54 to 15. In the case of steam turbines requiring a high degree of vacuum, the proportion will generally be much higher. This is important, and if the water supply be unfit for use in boilers without purification, it is quite clear that the gas plant scores still higher. With regard to the works cost items of wages, stores, repairs, and maintenance, the gas plant and engine do not involve any more skill or more attendants than steam plant, especially when all auxiliaries are taken into account. The producer requires no more skill than a boiler, and an unskilled man or ordinary attendant can as easily run a gas engine as a steam one. As a matter of fact, there is nothing to choose between the items of wages and running stores for the two plants, and while it is certain that in the earlier days of large gas engines, whatever the type, the repairs and maintenance account was exceptionally high, it is equally certain that this item is now but little, if any, higher than in the case of the steam engine. As regards the producers, this item is undoubtedly much less than for boilers, so that in the long run the balance is even between the two. One word about lubrication, which is popularly supposed to be excessive in gas engines—provided the lubricating arrangements are well carried out and a minimum amount of oil is applied at proper points, there is no cause to fear a heavier consumption than with steam engines.

The suction producer is certainly by far the cheapest to instal, consisting, as it usually does, of three elements only—the producer proper generally containing the boiler or vaporiser into which a small quantity of water is fed, and from which it is taken as steam to the fire-grate; the coke scrubber, used for cooling the gas and taking out the heavier dirt and tarry matter; and the sawdust cleaner for effecting final purification: this description is common to all suction producers except that the elements may be arranged somewhat differently.

The pressure producer for bituminous coal is a more expensive generator to instal on account of the large proportion of volatile hydrocarbon which is distilled from the coal as tar, and must be removed if the engine is to run satisfactorily. The presence of tar in the gas is not only prejudicial because it clogs up the cleaning plant, as well as the internal valve mechanism and other parts, but also because of the trouble which arises if particles of tar get lodged inside the cylinder. They incline to remain incandescent and ignite the incoming mixture at the wrong time, and also form an exceedingly hard carbonized scale, which tends to wear both cylinder and piston. Sulphur in the gas is most detrimental; it does not occur to any extent, as a rule, but if it does, and water be present, there is always risk of corrosion. Some cokes and some Continental anthracites have this objectionable quality, but, generally speaking, it does not often occur in British coal.

As to regularity of turning moment of gas engines, the difficulties of this have generally been overcome; they certainly did exist, sometimes in a most marked degree, with the old single-acting type of engine; but there are double-acting two-cycle gas engines coupled direct to and driving three-phase fifty-cycle alternators in parallel with perfect synchronism, which the author has seen, and he has actual knowledge of other similar gas engine sets running in parallel with each other and with steam-driven alternators.

The author concludes with a summary of actual results substantiating the foregoing remarks concerning reliability and economy. These include:

A plant consisting of two engines capable together of giving 500 electrical horsepower continuously at the switchboard. The calorific value of the bituminous coal used during three recent tests, each of twelve hours duration, averaged 12,250 b.t.u. per pound, and the gas varied between 140 and 152 b.t.u. by analysis. The fuel consumption in the producer averaged 1.3 lb. per kilowatt-hour, a most remarkable result. The engines have run for many weeks continuously, with rare stoppages, from 7:30 a. m. on Monday, till noon on Saturday, and operate in parallel with steam-driven sets situated in another engine room.

The engineer states that the cost per kilowatt-hour works out distinctly cheaper than if produced on the high-speed steam plant, in spite of the fact that the capital charges per unit on the gas plant are distinctly higher than they will be when it is brought up to its full capacity of 1,000 e. horsepower.

From a large iron works in the Midlands, the manager writes:—"It may interest you to know that formerly (with steam) we used about 2,000 tons of coal, costing us about £1,020 per annum, whereas now (with gas engines and bituminous coal pressure plant) we are using about 326 tons, costing about £195." This means a reduction to one-fifth of the original fuel bill; but it is only fair to point out that the old steam engine plant was admittedly uneconomical.

In another case, where a 500 b. horsepower gas plant replaced a steam plant of equal capacity, the saving is one-third of a penny per b. horsepower-hour, which, at ten hours a day and 300 days a year, is equivalent to about £2,000, notwithstanding the fact that a greater amount is allowed for depreciation on the gas engines than was allowed for the steam.

Several tests were carried out on a gas plant aggregating about 1,000 horsepower. The engines have been driving dynamos for some time now, and the results showed that the fuel (Yorkshire) gasified per kilowatt-hour was 1.43 lb. on full load and about 1.47 on three-quarter load.

The following two cases are from Mr. Dowson's interesting work on "Producer Gas." At the Birmingham Small Arms Factory, with a 250 b. horsepower plant, the total fuel consumed was 1.9 lb. per kilowatt-hour, and the total water used in the gas plant (not the engine) was one gallon per kilowatt-hour. At the Hoffman Manufacturing Company's Works, at Chelmsford, a test run of 123 hours was made without a stop, and readings were taken every half hour. The consumption of anthracite peas in the suction producer worked out at 1.23 lb. per kilowatt-hour.

At the Guernsey Electricity Supply Company's station, visited about two years ago, and which at that time was run at very light load, the figures for total working cost come out to practically 0.5d. per unit.

In a works where a 270 b. horsepower gas engine was installed at the beginning of last year, the gross coal consumption, taken over ten days on irregular load, and including stand-by losses, worked out at about 0.9 lb. per b. horsepower hour on an average of about three-quarter load. This engine is driving a mill, but if it were driving a dynamo having 93 per cent. efficiency, you will see that this works out at under 1.3 lb. per kilowatt-hour. In this case the gas plant consumes from one-sixth to one-seventh of the coal formerly used in the steam plant; but the latter was not of modern or economical design.

In another and larger plant, the total generating costs work out, on three months' ordinary running, at 0.135d. per unit, probably the lowest actual working costs on record. The load is certainly steady and continuous; but to even double or treble this figure, to contrast the running of this plant with one having the load-factor of an average Corporation station, one gets a generating cost much below that of any steam station having units within the limits of size which we have been discussing.

Individual tests on gas plant for short periods are perhaps unconvincing, especially, of course, with regard to reliability. They are, however, directly comparable with similar

tests on steam plant as far as coal consumption goes. The author has certified reports of the following: 1.43 lb. of coke per kilowatt-hour; 1.23 lb. anthracite per kilowatt-hour, with a further test on the same plant of 1.29 lb. per kilowatt-hour, and seven and a quarter gallons of total water consumed per b. horsepower-hour; another of 1.03 lb. coke per b. horsepower hour, and so on. On a 350 b. horsepower gas plant driving cement works in Germany, 1¼ lb. of very low grade lignite briquettes were used on a long test run per b. horsepower-hour.

Finally, there are the results of operating the Schwerin Electricity Works, where two 350 b. horsepower gas engines are used for driving direct-current machines for lighting. Taken over the whole first year of operation the gross coal consumption, including all losses and stand-by charges amounted to 2.2 lb. per kilowatt hour, while during the first six months of 1906 the average gross coal consumption per unit generated not on specific tests, but in actually weekly running, was 1.9 lb. per kilowatt hour, and that on a very poor load factor.

THE MUSIC OF ELECTRICITY.

"'We are merely at the threshold of the door leading to wonders in the world of science undreamed of to-day,' said Mr. Edison a couple of years ago. 'This period will go down in history as the guessing age in the realm of electricity.'

"Even while Mr. Edison was saying this, a wonderful invention, giving to the world the music of electricity, was in process of perfection at Holyoke, Massachusetts," states the "Electric City.

"The telharmonium, the latest invention in the electrical and scientific field, is a remarkable combination of new dynamos, transformers, wires, transmitters and keyboard, producing perfect music. Dr. Thaddeus Cahill, in his invention, has practically realized the dream-prophecy of Edward Bellamy in his 'Looking Backward,' by building a plant which will supply music to thousands of halls, homes, churches, hotels, offices—the list is limitless—by simply turning a switch, even as described by Mr. Bellamy:

"'She, crossing the room, merely touched one or two little screws, and at once the room was filled with the music of a grand organ anthem; filled, not flooded, for by some means the volume of melody had been graduated to the size of the apartment.

"'Such music, so perfectly rendered, I had never expected to hear.

"'As she spoke, the sound of violins filled the room with the witchery of a summer night. When this had ceased, she said:

"'"There are a number of music rooms in the city, perfectly adapted accoustically to the different sorts of music. These halls are connected by telephone with all the homes of the city whose people care to pay the small fee, and there is none, you may be sure, that do not.

"'"The corps of musicians attached to each hall is so large that, although no individual performer, or group of performers, has more than a brief part, each day's programme lasts through the twenty-four hours."'

"And now to turn from fiction to fact; from the poetry of the imaginative novelist to the performance of the creative inventor. While the system of the telharmonium may seem complex, it is, like all other great innovations, based on simple principles. Moreover, the telephone, by means of which the music is brought to the audience or the individual listener, has been familiar to the public for thirty years, and has become, with all its wonderful ingenuity, one of the essential commonplaces of modern civilization.

"The Cahill telharmonium has a range within which all other instrumental music is encompassed, yet presents a new music, all its own. The performer at its keyboard, instead of playing upon the flowing air in the sympathetic pipes of an organ, plays upon the electric current generated in a number of small dynamo-electric machines of the alternating-current type, each, so to speak, corresponding to a pipe. These are all mounted together on one shaft, which is revolved by an electric motor, thus securing steadiness at a high speed. The current in the circuits of these little 'inductor' alternators surges to and fro at a very considerable rate of 'frequency,' analogous to vibration, and each alternator is so designed as to have a characteristic vibration of its own. Thus, the middle C on the piano is produced by the vibrations of the string that is struck, and those vibrations are always 256 per second. In the telharmonium there is one dynamo, whose alternating current vibrates at just that rate, and when heard in the telephone, the current gives the note known as middle C always, and all the time, so long as the telephone remains in circuit. But in order to enjoy a musical composition, we want to hear not simply one note, but other notes, softly or loudly played, long-sustained or crisply-touched, and so the circuits from the dynamos are all brought to the keyboard, where the performer, just as though he controlled a number of valves or gates, lets in or shuts out the currents he needs, and of course only those thus introduced into the telephone circuit are the ones heard.

"Further, each note in music has, as is well known, its enriching vibrations in multiple of the fundamental number, so that one 'harmonic' will be the result of 512 vibrations, or twice 256, and the next higher will be one of 1,024; and so on through the octave. Obviously all this is easy to reproduce in the alternations of current, so that by means of these dynamos one has command of all the complexities and interweavings of tone color—the ability to analyze, synthesize, separate, blend. The performer, subject only to the limitations of his own skill and temperament, is at liberty to impress upon the surging waves of current the ebb and flow of his most intimate emotion, as he can do with no other medium of sound production. With the telharmonium he not only can suppress at will by omission, when not required by texture of sound, even the fundamental note, but can select by fine inclusion the subtlest overtones, as a basis for his innermost art of tone building.

"Yet another beauty of perfection emerges as this unique invention is studied—the wonderful quality of the tone, a tone absolutely pure, and soft and rich; a delight to the ear, and a rest for tired nerves. Hitherto in telephonic reproduction of music, the notes of the piece, played at one end of the line, have had to be taken up by the telephone transmitter, and, after passing through the circuit as undulatory waves of current, be again transformed into music at the receiving end. This has involved serious irreparable loss in volume. purity and beauty. But, in the telharmonium, the reproducing is also the performing instrument; its undulatory waves of current are themselves the 'music of the spheres' generated by the little dynamos. There is admittedly great beauty in the music from a phonograph or graphophone record, but that again is reduced and altered by the processes it goes through. As compared with telharmonium music it is but 'canned goods,' instead of coming fresh from orchard or garden. At each use, the edge wears off the phonograph cylinder, as it does off a coin in circulation, but with the telharmonium each new production of wave current and sound is as vivid and original as its predecessor, and can never be otherwise.

"And then—greatest fact and cause of wonder—is the ease with which this music of the telharmonium is deliverable instantaneously and simultaneously at ten or twenty or thirty thousand places, from the same central music plant.

"Think of the audience thus brought within reach of one human being! At best, an orator, an opera singer, or a pianist can sway but a few thousand people, and the average audience is only a few hundred. But the telharmonist, in addition to the audience that may chance to be in the room

where he is playing, reaches out over the pulsing wires to a hundred thousand, five hundred thousand, a million persons, all able to hear him at once, and while he may not shake the ground, as does deep-toned Niagara, he can make square miles of humanity respond to his tender and melodious tones. Here the music enlivens a dinner party, elsewhere it assists at a wedding; not far away it soothes pain in the house of suffering; while all over town, innumerable homes will be brightened and made cozier by the 'music on tap.'

"Mr. Andrew Carnegie has an organist play while he takes his morning bath. Soon every citizen may turn on his music at the moment he rises; and at night the same soft sounds will soothe him to slumber after he has turned off the light. All this may sound fanciful, but the telephone that was derided as a toy is now in countless numbers of homes and offices between Coney Island and Golden Gate, and millions of people can talk with each other. Over every one of those same wide-flung circuits the music of the telharmonium is feasible and possible."

THE USE OF ALCOHOL AND GASOLINE IN FARM ENGINES.*

Sources of Power.

There are two great sources of power and an infinitely varied series of mechanical devices and machines for the generation of power. Water power always has been used and probably always will be used so long as the rain falls, but it is insufficient for our present needs or geographically unavailable. The greatest source of power is fuel. Fuels may be divided into two series—those that now exist in the form of natural deposits and those which are being produced continuously. All of the coals, hard and soft, with the lignites and peats, the crude oils and natural gas, exist in the form of deposits; and, while it is true that the decay of vegetable matter may be today forming more deposits of the same nature, it is equally true that we are using the present supply faster than the rate of production. The newest fuel for power purposes is alcohol. This is made from the yearly crops of plants. There is in existence no natural deposit of alcohol, but in a sense it may be said to be possible to produce inexhaustible supplies.

It is only within recent time that engineers have known how to build engines that would produce power from alcohol; and still more recent is the further discovery by engineers that this power can be produced at a cost which may permit its general introduction.

By far the largest part of the power now being used comes from steam produced by the use of coal. This is chiefly due to the fact that as a rule whenever it can be used it is cheaper than possible substitutes, although it is partly due to the fact that steam power is better adapted to some classes of work and is older and better known than power generated by the gas engine in its varied forms. In point of present use, water power stands next to steam in importance. This is largely due to the fact that water power is among the earliest in point of development, but more largely to the fact that it has become possible to transform water power into electrical power, which can be transmitted long distances, and so overcome geographical isolation of the sources.

Next in quantity produced stands power generated by the gas engine. This class of engines includes all machines in which the fuel mixed with air is burned or exploded within the working chambers, whether the fuel be gas produced from coal, natural gas, vapors of any of the mineral oils, vegetable or animal oils, or alcohol. The subordinate position occupied by this source of power is due partly to the fact that engineers have only recently discovered, and are today discovering, how best to build these machines and adapt them to the work they are to do. Wind and wave power stand at the foot of the list and always will, so far as quantity of power developed is concerned. This is because of the irregularity of the sources of supply and their comparatively feeble nature.

*Abstract from Farmers' Bulletin No. 277, issued by the U. S. Department of Agriculture by Chas. Edward Lucke and S. M. Woodward.

Comparative Cost of Power From Different Sources.

The cost of producing power from any of the above sources is made up of a number of items, including interest on the first cost of the installation, depreciation of the apparatus, its insurance, etc., usually called the "fixed charges." To these should be added the costs of fuel, of labor for attendance, and of repairs, as the principal items, and the cost of lubricants, material for cleaning, and a great many other small miscellaneous items, all going to form what are commonly called "operating charges." In all cases where fuel is used its cost is, if not the most important, certainly a very important item. In the case of water power, where the fuel element is zero, the advantage is offset by an interest charge on the cost of installation for dams, pipes, tunnels, shafts, etc. Assuming that power from all of these different sources is equally well adapted to the particular work to be done and equally available, then that system will be selected for any particular case for which the cost of power is least. Leaving out of consideration water power, it is found that the labor costs do not differ nearly so widely for the different systems, nor are they so large, as the fuel cost. Therefore, the great question today in power production as regards immediate cost of power and maintenance is this lowering of the fuel cost.

The cost of fuel per unit of power developed depends, first, on the market price of that fuel at the point where it is to be used, and next, but by no means least, on the ability of the machinery to transform the fuel energy into useful work. If all the different kinds of machinery used for power generation could turn into useful work the same proportion of the energy in the fuel, coal would be almost universally used, because of the present low cost of energy in this form.

Comparative Cost of Energy in Different Fuels.

The different kinds of fuel contain different amounts of energy per pound—that is to say, they have different heating powers. Heat energy is measured in terms of a technical unit called by English-speaking people the "British thermal unit" (B. T. U.). This unit is the amount of heat that will raise the temperature of 1 pound of water 1 degree on the Fahrenheit thermometer. In comparing, therefore, the value of fuels for power purposes there must be taken into consideration two facts—the market price of the fuel and the amount of heat which will be liberated when it is burned. Anthracite coal in the neighborhood of New York can be bought in small sizes in large quantities for power purposes at about $2.50 per ton. This coal will contain about 12,500 B. T. U. per pound. This is equivalent to about 10,000,000 heat units per dollar. Large sizes, such as egg coal, containing about 14,000 B. T. U. per pound, can be bought in large quantities for about $6.25 per ton, which is equivalent to 4,500,000 B. T. U. per dollar. Other grades of anthracite coal and the various grades and qualities of bituminous coal will lie between these two limits of cost. Illuminating gas in New York costs $1 per 1,000 cubic feet, which is equivalent to about 500,000 heat units per dollar. Natural gas in the Middle States is sold for 10 cents per 1,000 cubic feet and upward. This fuel at the minimum price will furnish about 10,000,000 heat units for a dollar. Crude oil sells in the East at a minimum price of 4 cents per gallon, which is equivalent to about 4,000,000 heat units per dollar. Gasoline sells at a minimum price of 10 cents per gallon, which is equivalent to about 1,200,000 heat units per dollar. Kerosene sells from 10 to 30 cents per gallon, which is equivalent to 1,200,000 and 400,000 heat units per dollar, respectively. Grain alcohol,

such as will be freed from tax under the recent legislation, will sell for an unknown price; but for the purpose of comparison, assuming 30 cents per gallon as a minimum, it will give 270,000 heat units per dollar. Gasoline, kerosene, crude oils, and, in fact, all of the distillates have about the same amount of heat per pound; therefore, at the same price per gallon, ignoring the slight difference in density, they would deliver to the consumer about the same amount of heat per dollar, whereas the other liquid fuel, alcohol, if sold at an equal price, would give the consumer only about three-fifths the amount of heat for the same money. From the figures above given it appears that the cost of heat energy contained in the above fuels, at the fair market prices given, varies widely, lying between 200,000 heat units per dollar and 10,000,000 heat units per dollar. It is possible to buy eight times as much energy for a given amount of money in the form of cheap coal as in the form of low-priced gasoline, or twenty-five times as much as in the form of high-priced gasoline or kerosene. This being true, it might seem to a casual observer as rather strange that gasoline should be used at all, and the fact that it is used in competition with fuel of one-eighth to one-twenty-fifth its cost shows clearly that either the gasoline engine has some characteristics not possessed by an engine or plant using coal, which makes it able to do things the other can not do, or that more of the heat it contains can be transformed into energy for useful work. Both of these things are true.

Thermal Efficiency.

As was pointed out before, the different kinds of machinery used to generate power render more or less of the fuel energy into useful work; all systems do not give equal returns for equal amounts of heat supplied. If all the heat energy in fuel were transformed into work with no losses whatever in the mechanism, the machinery would be said to have a thermal efficiency of 100 per cent, and it would require 2,545 heat units per hour to maintain an output of 1 horsepower. If half of the energy in the fuel were lost in the machinery, its thermal efficiency would be said to be 50 per cent, and there would be required 5,090 heat units per hour. If only 1 per cent of the heat energy in the fuel were transformed into useful work, the efficiency of the machinery or power plant would be said to be 1 per cent, and there would be required 254,500 heat units per hour to maintain 1 horsepower.

Steam plants in use represent a great variety of styles or types, but in general it may be said that the more complicated and refined the plant and the larger its size the more efficient it is, because the complication exists only as evidence of an attempt to minimize the losses of heat in the machinery. Similarly the more steadily the plant works at the output for which it was designed the higher the efficiency of the plant, and conversely, the smaller the plant, the simpler the apparatus, or the more intermittently it works, the lower its efficiency. Steam-power plants are built today to do every conceivable sort of work, and range in size from 1 horsepower to 100,000 horsepower. For purposes of comparison neither the largest nor the smallest should be used, nor the best performance nor the worst performance of these plants, but a figure representing a fair average for the conditions named should be taken. Large steam plants in their daily work seldom use less than 2 pounds of poor coal per hour for each useful horsepower (known as a brake horsepower), which is equivalent to about 25,000 B. T. U. per hour, and which corresponds to about 10 per cent thermal efficiency. Small steam plants working intermittently, such as hoisting engines, may use as high as 7 pounds of coal per brake horsepower, which is equivalent to about 100,000 heat units per brake horsepower hour, or 2.5 per cent thermal efficiency. Some plants will do better than the above with proper conditions, and some may do worse, but in general it may be said that the performances of steam plants lie between the limits of 2.5 and 10 per cent thermal efficiency.

Plants consisting of gas producers for transforming coal into gas for use in gas engines have in general a much

Cost of Energy in Fuels.

Kind of fuel.	Cost of fuel.	British thermal units. (B. T. U.)	Number of B. T. U. bought for $1.
Small anthracite	$2.50 per ton	12,500 per pound	10,000,000
Large anthracite	6.25 per ton	14,000 per pound	4,500,000
Illuminating gas	1.00 per 1,000 cubic feet	550 per cubic foot	550,000
Natural gas	.10 per 1,000 cubic feet	1,000 per cubic foot	10,000,000
Crude oil	.04 per gallon	20,000 per pound	3,650,000
Kerosene	.10 per gallon	20,000 per pound	1,200,000
Do	.30 per gallon	20,000 per pound	400,000
Gasoline	.10 per gallon	20,000 per pound	1,200,000
Do	.30 per gallon	20,000 per pound	400,000
Grain alcohol	.30 per gallon	12,000 per pound	270,000
Do	.40 per gallon	12,000 per pound	200,000

Fuel Cost of Power.

Fuel and type of plant	Fuel required per horsepower per hour.	British thermal units required per horsepower hour.	Thermal efficiency.	Cost of fuel.	Cost of fuel per horsepower per hour.
Anthracite coal:			*Per cent.*		*Cents.*
Large steam plant	2 pounds	25,000	10	$2.50 per ton	0.25
Do	2 pounds	25,000	10	6.25 per ton	.57
Small steam plant	7 pounds	100,000	2½	2.50 per ton	1.00
Do	7 pounds	100,000	2½	6.25 per ton	2.20
Producer gas plant	1¼ pounds	14,000	18	2.50 per ton	.14
Do	1¼ pounds	14,000	18	6.25 per ton	.31
Do	2 pounds	25,000	10	2.50 per ton	.25
Do	2 pounds	25,000	10	6.25 per ton	.57
Illuminating gas	24 cubic feet	12,000	20	1,00 per 1,000 cubic feet	2.20
Crude oil	1.4 pints	25,000	10	.04 per gallon	.68
Gasoline	1.1 pints	13,400	19	.15 per gallon	1.70
Do	1.1 pints	13,400	19	.30 per gallon	3.40
Alcohol			a19	.30 per gallon	5.00
Do			a19	.40 per gallon	6.70

a Efficiency of alcohol is assumed to be the same as that of gasoline for identical conditions of use.

higher thermal efficiency than steam plants doing the same work. They are, however, not built quite so small as steam plants, the smallest being about 25 horsepower, and in general they have not been built so large, the largest being only a few thousand horsepower. Their efficiency, however, does not vary so much as is the case with steam plants. It may be fair to say that under the same conditions as above outlined these plants will use 1¼ to 2 pounds of coal of fair or poor quality per brake horsepower hour, which gives a thermal efficiency ranging from 18 to 10 per cent. These plants can be made to do much better than this, and perhaps may do worse, although the variation is not nearly so great as for steam plants.

Gas engines operating on natural gas or on illuminating gas from city mains will, on fluctuation of load with the regular work, average about 12,000 heat units per brake horsepower hour, or 20 per cent thermal efficiency. Exploding engines operating on crude oil will average about 25,000 heat units per brake horsepower hour, which is equivalent to about 10 per cent thermal efficiency. Exploding engines using gasoline should operate at a thermal efficiency of about 19 per cent under similar operating conditions.

The efficiency of an alcohol engine may be assumed at this time to be unknown, but as alcohol can be burned in engines designed for gasoline, it may be assumed that such an engine will have with alcohol fuel the same thermal efficiency as with gasoline, to-wit, 19 per cent for fair working conditions.

From the above brief discussion of the efficiency of different methods of power generation from different fuels it appears that quite a range is possible, though not so great a range as exists in the case of cost of fuel energy. Efficiency is seen to lie somewhere between 2½ and 20 per cent for all the fuels under working conditions. It is known that actual thermal efficiency under bad conditions may be less than 1 per cent and under the best conditions as high as 40 per cent, but these are rare and unusual cases. The range given is sufficient to indicate that a highly efficient method may make the fuel cost per unit of power less with quite expensive fuel than it would be with cheaper fuel used in a less efficient machine. It is also perfectly clear that without proper information on the efficiency of the machine or the efficiency of the plant it is impossible to tell what the cost of fuel per horsepower hour will be, even though the price of the fuel per ton or per gallon be known. From the figures given on the cost of fuel and a fair average for plant efficiency the cost of fuel per horsepower hour is computed as given in the preceding tables:

Adaptability of Various Types of Engines.

The foregoing table shows very clearly that the cost for fuel to maintain a brake horspeower for one hour varies widely, and at the prices given the dearest costs nearly 48 times as much as the cheapest. The fact that not everybody uses the fuel giving the cheapest power in point of fuel cost, but that even the most expensive finds a ready market, makes it clear that there must be good reasons. These reasons may be found in local variations in price of fuel, in differences in adaptability of the engines to the work required, and in the fact that the above figures show fuel cost only, whereas there are great differences in the cost of attendance. An elaborate steam plant, to be even fairly efficient, must be continuously operated at fairly heavy load; intermittent working or working at a decreased output makes them wasteful of fuel. Moreover, the apparatus is so complicated, slow to start up, and dangerous to life and property in careless or inexperienced hands that persons must become skilled by years of study and practice before they may be allowed the handling.

The gas engine with its producer can handle today the same kind of coal that is used in steam plants, and yet the weight of this apparatus and its lack of flexibility, compared with steam engines, make it unavailable for steamships and locomotives; so it is clear again that adaptability to service is even more important than the cost of fuel. Similarly, gas-producer plants have not yet been successful for sizes smaller than 25 horsepower, and especially unsuccessful have they been so far for intermittent work. For the small sizes the steam plant is also very wasteful of fuel, requires a skilled operator, and is slow in starting; so it is clear why engines burning crude oil, gasoline, kerosene, and other liquid fuels explosively should be used for light work in isolated stations where the work is intermittent and where quick starting and small care in attendance are essential. In this connection it must not be forgotten that a kerosene, gasoline, or crude-oil engine can be started in a few minutes and can even be left running for practically a whole day with only an occasional examination to see that the oil cups are flowing properly and the bearings are not getting hot through being dirty. Steam engines with their boilers, on the contrary, can not be started inside of one or two hours, and all the fuel necessary to raise steam is wasted so far as the work to be done is concerned. Moreover, a steam engine requires continuous feeding of coal and close attention, so that a man must be always near it, having no other duties but its care.

In the natural-gas regions a large number of gas engines are working and in the oil regions a similar number of oil engines and gasoline engines, because the nearness to the supply makes the fuel cheaper than transported fuel, and the exploding engine is more efficient than the steam engine.

It thus appears that in spite of the fact that the fuel element in the cost of power is high for engines burning crude oil, kerosene, and gasoline in comparison with those using coal, at the same time they possess advantages that do not exist in steam plants and gas-producer plants, which give them a very distinct field, as indicated by the following uses to which these engines are being put today: Driving boats, automobiles, and railroad motor cars; pumping water for private houses, for farms, for irrigation, and in some cases for municipal service in small towns; compressing air for drilling, hoisting, riveting, etc.; operating small carpenter shops, machine shops, forge shops, and, in fact, any kind of small shop; operating ventilating fans in buildings and in mines; running small factories, such as creameries and butter factories; operating feed-cutting and grinding machinery, corn shredders, and threshing machines; operating other special machines, such as ice-cream freezers, printing presses, mostly small in size, and making electric light in isolated localities. Not only is this field a real one, but it is a large one, as is shown by the number of these small engines being sold today. The exact figures on the sales are not available and it is impossible to secure them because of the unwillingness of manufacturers to tell their business; but when a single manufacturer (as is the case) is selling 425 per day, and there are in the United States alone some 300 manufacturers of importance, there can be no doubt as to the popularity of these machines.

Alcohol at a price unknown now becomes available for use in engines, whose peculiarities are not fully known and whose ability to transform heat into work is correspondingly in question. If the alcohol engine can be shown to have an efficiency as high or higher than other liquid-fuel engines and be similar in type and characteristics, it can do all they can do, and its field will be the same as their field in spite of fuel costs; but by field is meant the nature of the work rather than the geographical location. It is likely that the alcohol engine will find as favorable a geographical location as the natural-gas engine and the oil engine have near the source of supply and far from the source of competing supply. But should it appear that the alcohol engine can do more or better work than its oil or gasoline competitors, its field will be wider. In any case the position which the alcohol engine may take today is no criterion as to its future, because it will operate on a source of energy or fuel supply which, as

pointed out, is inexhaustible, whereas the supply of both crude oil and its distillates may ultimately become exhausted.

The determination, then, of the position of the alcohol engine today involves a forecast of the future, and should it be shown to be able to compete now it must inevitably reach a stronger and more important industrial position as time goes on. This is the fact that has led governments to take up the question, and among them the United States is the latest.

First Use of Alcohol Engines.

About the year 1876 there was placed on the American market the first successful internal-combustion engine using petroleum distillate. This engine was invented by George Brayton. Following the attempt of Brayton to use petroleum distillate came a series of inventions improving this class of engine, lasting for about twenty years, when the modern forms of kerosene, gasoline, and crude-oil engines may be said to have been developed. During this time the subject of alcohol as fuel in engines seems to have been either not thought of at all or not given any attention. The first serious attempt to examine into the possibility of alcohol as a fuel in competition with petroleum and its distillates seems to have been made in the year 1894 in Leipzig, Germany, by Professor Hartman for the Deutschen Landwirtschafts-Gesellschaft. The engine used was built by Grobb, of Leipzig, to operate on kerosene, and used 425 grams of kerosene per hour per brake horsepower, which is equivalent to 0.935 pound, or 1.1 pints, approximately. This indicates for the kerosene a thermal efficiency of 13.6 per cent. When operating on alcohol the engine used about twice as much, or 839 grams, which with this kind of alcohol was equivalent to a thermal efficiency of 12.2 per cent, or a little less than with kerosene. This experiment would seem to indicate that, compared with kerosene, alcohol, as a fuel, offered very little chance for successful competition. In spite of this, however, very vigorous efforts were made to develop an alcohol engine that would be better than this one, and thus was inaugurated a remarkable series of experiments, congresses, and exhibitions with the one end in view—of stimulating the production of the best possible alcohol motor.

The first stimulus was given by the German alcohol distillers, who sought to enlarge their market. They succeeded in interesting the German Government in the question by enlarging on the national significance of having available a source of fuel for power, inexhaustible in quantity, to be produced within the national domain from the yearly crops. Under the double stimulus of government assistance and the desire of the distillers to increase their output, inventors and manufacturers were induced to spend their time and money with a resulting decided improvement in the motor. An engine built by Kortink Brothers, of Hanover, fitted with a vaporizer invented by Petreano, tested at the Polytechnic School at Charlottenburg by Professor Slaby, showed a consumption of 550 grams of 86.2 per cent alcohol by weight, which is equivalent to 1.21 pounds, or 1.4 pints, or a thermal efficiency of 17.5 per cent. This result showed an advance of nearly 50 per cent in thermal efficiency over the Grobb engine tested a year or so earlier by Professor Hartman. Following this improvement there resulted a continual development of the alcohol motor, interest in which was kept up by exhibitions in which prizes were offered and by scientific societies.

Besides the above named, there were many others of lesser importance, all contributing to the rapid development of this class of machine.

The results of this development may be summed up by saying that the thermal efficiency of the motor was raised to something over 30 per cent, which is quite a remarkable showing in comparison with the original figure of 12.2 per cent in 1894. It must be clearly understood, however, in interpreting these figures that they are the best possible attainable at the time reported. They indicate, so far as the fuel costs are concerned, that with a motor specially constructed for alcohol the fuel prices per gallon might be twice as much for alcohol as for petroleum distillate and still give power for less money, assuming that attendance, repairs, lubrication, etc., cost no more in the case of the alcohol engine.

The Office of Experiment Stations of this Department, in connection with its Irrigation and Drainage Investigations, has tested a number of different types of gasoline engines with alcohol and obtained figures which show the comparative consumption of gasoline and alcohol in the same engine. The detailed results of these tests will be published in a technical bulletin, but the general results may be given here. The first tests were made without any particular attempt at obtaining the best adjustment of the engine for each fuel, and showed a consumption of alcohol two to three times as great by weight per horsepower hour as was necessary with gasoline or kerosene. These figures indicate the necessity or desirability of determining the proper conditions of adjustment, because these were found to have a serious influence on the amount of fuel consumed. With care in adjusting the engine so as to secure the most economical use of the alcohol, it was found that, under like conditions, a small engine consumed 1.23 pounds of alcohol to 0.69 pound of gasoline per brake horsepower hour—that is to say, with the best adjustment of the engine for each fuel there was required 1.8 times as much alcohol by weight as gasoline per brake horsepower hour. It was also shown in making this adjustment that it was possible to burn more than twice as much alcohol as stated, by improper adjustments, and still have the engine working in an apparently satisfactory way. The range of excess gasoline which might be burned without interfering seriously with the working of the engine was not so great, being a little less than twice as much as the minimum. These early experiments, therefore, confirmed the early results secured in Germany, to-wit, that an engine built for gasoline or kerosene will, when unchanged, require about twice as much alcohol by weight for the same work; but they also indicate something that is not pointed out by the reports sent us from abroad—that is, the great importance of securing the best adjustment of the machine.

ADVANTAGES OF CRUDE OIL.

Of the crude oil which is raised—some $20,000,000 tons per annum—about one-fifth is used for heating purposes. For these purposes, crude oil presents, as compared with coal, the advantages of greater heating value, smaller storage room, less labor, easy transport, regularity of action, smokelessness and absence of sulphur and corrosion of boilers; but in some countries the cost of it outweighs these advantages. In Russia, Austria, and Pennsylvania it is largely used for locomotives. Herr F. Heintzenberg gives the following as the heating values per pound, in pound-centigrade units: Recent coal, 6,500; older coal, 7,500; Paris gas tar, 8,900; shale oil, 9,000; American petroleum, 9,770; Pennsylvanian light naphtha, 9,960; Pennsylvanian heavy naphtha, 10,670; Baku light naphtha, 11,460; Baku heavy naphtha, 10,800; Belachany naphtha, 11,700.

A UNIQUE GAS MANTLE.

M. Emile Louis Andre has put forth a curious idea, and, what is more, he has patented it in France. He uses an egg-shell, literally an egg-shell, as an incandescent mantle, for acetylene flames. It does not shatter or break, he says. and it gives a pleasant soft light. All the preparation that is needful is to make a hole at each end of the shell, and to put the shell in position with the burner inside. The burner head throws out lateral flames which impinge on the interior of the egg-shell.

UNDERGROUND TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY.

By Charles E. Phelps.*

The faults in underground cables naturally classify themselves as follows:

1. Defects in the cable itself.
2. Injury received during installation.
3. Faulty workmanship.
4. Mechanical injury.
5. Electrolytic action.
6. Certain external injuries, the cause of which may not be conclusively established.

And to these six may be added the injuries which occur to cables not strictly underground, but which are above the surface of the ground on poles, etc., making connection with aerial conductors. This latter is uniformly the result of imperfect covering protection, or results from contact with the cable sheath of aerial wires; they can hardly be classed with the faults of underground cables.

Referring to the other six classes of faults, the first three, viz:

1. Defects in the cable itself,
2. Injury received during installation,
3. Faulty workmanship,

should be sufficiently provided against in the contract for the cable and in the character of conduit construction, that they may be developed on the break-down test which is invariably applied to a completed cable before putting it into continuous service. This test usually requires that at least double the ordinary working voltage shall be applied to the insulation of the cable; that is, between conductors and ground, for various periods of time, depending upon the judgment of the purchaser and acquiescence of the contractor. The test should never be pushed to a point where the insulation is liable to be pin-holed by the strain of the test voltage, and experience has generally pointed to the continuance of the test voltage for from one to two minutes' duration, instead of thirty or more minutes which have often been specified. Under this test the defect should be developed and the obligation should, by contract, be imposed upon the contractor to make it good. If it should have been caused by any defect in the conduit construction the cable contractor would, of course, be blameless. The other faults:

4. Mechanical injury,
5. Electrolytic action,
6. Damage to cable above ground.

All these are of purely external cause.

In order to illustrate this feature more prominently, below is given a tabulated record of the cable faults in this city for the seven years ending December 31, 1906, together with the lengths of cable in use in each year. This tabulation includes all classes of cables:

13,000 = volt, alternating-current, three-conductor cable.
6,600 = " " " " " "
2,300 = " " " " " "
1,000 = " " " two- " "
500 = " street railway feeders,
250 = " three-wire distribution,
Telephone cables from 5 to 400 pairs,
Telegraph " " 20 to 200 wire,

and various smaller cables used for burglar and fire alarm and other signalling purposes, including the police and fire alarm wires of the city. In fact, the table includes injuries to all those classes of wires which are found to be necessary in the activities of any large and growing city. Summarized by classes of faults and by years, the table is as follows:

Cl'ss	Nature of damage	1900	1901	1902	1903	1904	1905	1906	Total
1	Defective Cable	—	1	—	—	—	2	—	3
2-3	Damage during installation	—	—	—	3	7	4	10	24
4	Damage by picks, bars, etc.	—	2	6	6	13	27	4	58
4	Flood water, Jones Falls.....	—	—	—	1	—	1	—	2
4	Gas explosions	1	—	—	—	1	—	—	2
4	Rats	—	—	—	—	—	—	5	5
4	By workmen in manholes.....	—	—	—	2	3	4	4	13
5	Electrolytic	1	—	2	15	5	4	4	31
6	Cables above ground.....	—	1	1	—	—	—	—	2
7	Unknown.....	—	—	—	—	—	7	1	8
	Totals.....	2	4	9	27	29	49	28	148
Feet of cable in operation at end of each year.....		106,779	236,266	470,154	708,152	853,948	1,246,443	1,535,294	
Fault per 1000 ft. of cable		0.018	0.017	0.019	0.038	0.034	0.039	0.018	

It should be noted in connection with the table above given that damage under head of gas explosions was not the immediate result of the explosion, but was caused by the falling of debris and burning gas. No cable has been directly injured from any gas explosion under observation. Also, that the damage under "Flood Water—Jones' Falls" was due to the carrying away of cables on temporary suspension under a bridge crossing Jones' Falls, by heavy timbers carried down by flood water.

Summary of Cable Faults.

Class	Nature	Number of faults	Per Cent of whole
1.	Defective cable	3	2
2.	Damaged in installation.....	24	16
3.	Mechanical injury	80	55
4.	Electrolytic action	31	20
5.	Cables above ground	2	1.5
6.	Unknown causes	8	5.5
		148	100

The percentage in importance of each class of fault to the whole number is:

1. Defective cables ..... 2 per cent.
2. Damaged in installation .....16 "
3. Mechanical injury .....55 "
4. Electrolytic action .....20 "
5. Cables above ground ..... 1.5 "
6. Unknown . . .. 5.5 "

This is for the whole period of seven years; the record of the year 1906, just past, during which time there were over 1,500,000 feet of cable in operation, is as follows:

1. Defective cables .....none
2. Damaged in installation 10
3. Mechanical injury 13
4. Electrolytic action 4
5. Cables above ground .....none
6. Unknown 1

18

a total of 28 or —— per 1,000 feet of cable in operation.

1000

In considering the tabulations of cable faults, these data must be understood to show actual existing and not sporadic conditions; that not only do they cover a considerable period of time, but they cover, also, a time during which progress in this particular branch of the art was undergoing great changes. A part of the time may even be taken as experimental. In addition to this, the data for the years 1904 and

*Abstract from an address given before the American Institute of Electrical Engineers.

1905, shown in these tables, will suffer in its application to a normal situation by reason of the apparently high percentage of faults developed on account of mechanical injury.

Out of a total of 80 faults by mechanical injury for seven years, exactly one-half, or 40 of them, occurred during the years 1904 and 1905, although in 1906 there were but four, while the amount of cable in use was much greater.

This disproportion is easily explained by pointing out that during 1904 and 1905 all street improvements consequent upon the fire of February, 1904, were carried out. Street lines and grades were changed, necessitating a similar change in conduits and of cables within them. A great many men were employed upon all sorts of work, and, naturally, the underground system has to stand its share of damage.

In studying the list of cable faults you will see that, barring the sole element of human frailty, all the faults may be to a large extent anticipated, and in a large measure avoided. By analyzing these failures, you will find some definite reason for each of them to which a remedy can be applied. I do not intend to convey the impression that a cable system can be developed which will never be fault-proof, because the conditions under which it is operated are not those of a parlor game; but one has to deal with men and materials that are by no means perfect.

I can perhaps illustrate the conclusion which I desire to convey to you. Suppose, say, twenty important companies on this continent engaged in the same character of electrical business were to keep accurate records of the performance of their underground equipment under actual operation, with clear explanation of the conditions surrounding and the effect of each cable fault, and suppose that all these twenty separate sets of data were available to each one of the companies concerned, so that each would have, in addition to its own data, those concerning the cable performance of nineteen other companies. Suppose, now, you had these data in hand, what would be the result? You would eagerly search out those of the companies which showed few faults where you were subjected to many of the same kind, and you would get in touch with them and learn in what particular they had succeeded where you had failed. In the same way you would be called upon to explain your successful methods to certain others who had failed where you had succeeded. This is a process which seems so easy, so simple, and so inexpensive when the great benefits that would accrue are considered, that it seems surprising it is not an almost universal custom. I cannot refrain from backing up this statement by saying that this spirit of co-operation and co-ordination is one of the important elements which has maintained the pre-eminence of the Bell Telephone Company in its particular field of operation, judging solely by results from the point of view of an outside but interested observer.

Before closing this paper I ask your consideration to a brief review of this particular subject, which may really be termed the crux of the whole situation. Taking the cable faults in the order they appear on the chart, the first three:

1. Defect in cable itself,
2. Damage during installation,
3. Faulty workmanship,

should be covered by the contract for purchase and installation of cable, and they should be "smoked out" by the installation test before described. Owing to the fact that the factory test of cable before shipment is much more severe than the installation test, and that the factory test is made on the cable while submerged in water, it is more than probable that any fault developed in the body of the cable itself will be caused either during shipment or during installation.

It will generally be impossible to determine on light and power cables, which was the real cause, for the effect of the break-down is to destroy the evidence entirely; the affected part of the cable will vanish to parts unknown.

Faults due to installation are, in general, due to four causes:

1. Defective conduit structure,
2. Reckless or improper methods of pulling cable into ducts,
3. Rough handling or too sharp bends in manholes,
4. Badly made joints.

I think it sufficient simply to enumerate these causes to indicate the prevention or remedy.

Faulty workmanship may occur either during installation or later, due to additional taps or connections being made to an existing cable. Here the remedy, aside from the employment of only skilled and careful workmen, is to provide a manhole suitable for the conditions under which this work is to be done. There should be plenty of elbow-room, and cleanliness is one of the best friends to the underground cable. Even in a city without sewers, the expense of consistent drainage of manholes by expensive methods is justified.

Mechanical injury may come from without through the agency of the energetic man with the pick who generally never works so hard as when he is hacking away at something he has no business to hack; or it may come by reason of improper use of the manhole by workmen; or from such an unusual source as the despised rat, which has been dignified by what I hope are five obituary notices in our exhibited list, under the year of 1906.

I hardly feel able to point out any remedies against this prolific cause of cable trouble that have not already, perhaps, occurred to you, but there is one which comes from within and which often and unnecessarily results in trouble and is easily avoided. This, as is usually the case with internal cable troubles, concerns the manholes. I have myself recently seen inside the manholes of an important underground system where the cables therein were so run through the manholes that it is impossible for a workman to get to the floor of the holes without using these cables as a step ladder. This was the case, not in a single manhole, but in many of them. Apparently the manholes were built simply because every other underground system had them, and they exhibited utter disregard of their permanent use by the cable equipment for which they were built.

LIGHTNING EFFECTS ON TELEPHONE POLES.

In the "National Telephone Journal" for February there are some interesting particulars of the effects of lighning upon the outside equipment of the National Telephone Company, which were observed in Nottingham last summer. The following is a noteworthy occurrence: During a heavy thunderstorm last summer one of the company's poles, just erected, but carrying no wires, was struck by lightning. The earth wire, with the exception of about 8-inch coiled round the pole near the top, had completely disappeared, and no trace of the staples which originally held the wire could be found. At the point where the staples had been fixed the pole was punctured as if by climbers, but the holes were bigger than those ordinarily made by climbers. A hole 2 feet deep was made in the ground where the earth wire entered. The hedge on the roadside, which was close to the pole, was badly scorched. The nails holding the roof on the pole were withdrawn to about half their length, but the roof was not damaged. The pole itself did not appear to be damaged otherwise than by the apparently sudden fusing of the staples. Three holes about 1 foot deep and 1 foot in diameter were made in the ground on the opposite side of the ordinary roadway of the pole. Another incident occurred during the building of the same route. About two miles of wire had been erected on the poles, and left "dead" on the insulators at one end. At the other end the wires came down from the pole in coils, which were hung on a wooden fence. When the men went to pick up the coils to proceed with the works, they received shocks similar to those from a Leyden jar discharge. The weather was cloudy and thundery, although no storm was taking place at the time.

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EDITORIAL.

Modern Elecrrical Generators and Converter Systems

The high-tension committee of the American Institute of Electrical Engineers is responsible for two short articles to serve as introductions to the discussion of these papers, to be held at a special meeting of the Institute, in New York, on March 22nd. "Motor-Generators vs. Synchronous Converters," with special reference to operation on long-distance transmission lines, is treated by Mr. P. M. Lincoln. The other paper, entitled "The Practicability of Large Generators Wound for 22,000 Volts," is by B. A. Behrend. Both of these subjects are of considerable interest to the electrical engineers of the West.

Mr. Lincoln, in his treatment of the subject of the transformation or conversion of electrical energy from alternating to direct current, states that the problem is practically that direct current of approximately constant voltage, either for electrical railways from 500 to 700 volts, or for incandescent lighting systems from 100 to 275 volts, or for electrolytic processes at any voltage, covers the requirements as far as the utilization of the electrical energy, while the source of power is necessarily alternating current at from twenty-five to sixty cycles, the voltage at the point of delivery being subject to considerable variation.

In comparing the motor-generator with the synchronous converter, the points considered are given as follows in the order of their relative importance from the author's standpoint:

1. Reliability.
2. Voltage regulation.
3. Corrective effect.
4. Efficiency.
5. Cost.
6. Parallel operation.
7. Starting.

Without going into the details of the facts and arguments presented by Mr. Lincoln, he concludes that for reliability, efficiency and less first cost, the synchronous converter has distinct advantages; that for parallel operation, the two systems are practically on an equal basis and that for voltage regulation, corrective effect and convenience and ease of starting, the motor-generator has the advantage. Further, it is the author's conclusion that there are probably but few cases where the motor-generator should be used preferably to the synchronous converter.

It is questionable whether Mr. Lincoln's conclusions will receive the unqualified endorsement of the engineers identified with the installation and operation of the long-distance transmission lines of the Pacific Coast. This is probably in a large part due to the fact that a frequency of sixty cycles has been adhered to almost entirely in the large central California plants, while fifty cycles is to be found in practically all of the transmission systems of Southern California. It is also to be remembered that direct current for railways is not now limited to between 500 and 700 volts. In the near future it is very probable that for the interurban street railway systems 1,200 volts will be substituted on long direct-current lines. With the comparatively high frequency of sixty cycles and 1,200 volts direct current required, it would seem from the experience of engineers in long transmission lines that the motor-generator should give much better all-round service than the synchronous converter.

It will probably be found that the placing of reliability first in the requirements of energy conversion will appeal most strongly to operating engineers. Where a number of generating plants are connected to a network of transmission lines, and particularly during the winter season, interruption of service, or, at times, great fluctuations in voltage are not uncommon. For voltage regulation and reliability of operation, certainly the motor-generator set has a great advantage over the synchronous converter.

By "corrective effect" is meant the voltage regulation of the transmission line by means of the change in the power factor of the current taken. This matter is of great importance, as the length and voltage of the transmission lines are increased. Ordinarily an induction motor would provide sufficient inductive current to offset the charging current in the line. However, the power factor of the induction motor is not subject to regulation or adjustment, while with the synchronous motor or synchronous converter, the range of adjustment of the power factor is consider-

able, and both can be operated with either leading or lagging current in a varying degree.

The reliability of operation, possibility of voltage regulation and the corrective effect, taken together, are certainly of much more importance than the combination of high efficiency, less first cost, ease of parallel operation and normal conditions during the starting of the machines.

Mr. Behrend's paper is of interest as showing the tendency in the construction of large units. The four types of prime movers considered by him are as follows:

1. Hydraulic Turbines.
2. Gas Engines.
3. Reciprocating Steam Engine.
4. Steam Turbines.

The author considers that generators exceeding 7,500-kilowatt capacity, operated by hydraulic power, will be comparatively few, and that the same thing may be said in connection with the gas engine. Also that the reciprocating steam engine is not as well adapted to very large units, namely, 7,500-kilowatt or larger, as is the steam turbine, the reason being that with the steam turbine comparatively high speeds are possible.

With large units, from 7,500-kilowatt to, possibly, even 25,000-kilowatt, there can be no reason why the voltage of the machine should not be from 20,000 to 25,000 volts. The matter of insulation of the conductors of the armature is simply mechanical, and as the size of the generator is increased without increasing the armature current, the insulation of the armature conductors becomes relatively less difficult.

From the standpoint of the operating engineer, there can be no question of the advisability of increasing as greatly as possible the generator voltage. Step-up transformers not only increase the first cost of the building and equipment, but introduce difficulties, particularly where burn-outs are liable from lightning or other electrostatic disturbances. If the long-distance transmission systems on the Pacific Coast were to be built to-day, in the light of the experience which is now available, units of from 5,000 to 10,000 kilowatts would be installed in place of the many small machines that are now in operation. All of the generators would be of the rotating-field type, and many would have an initial voltage of from 6,000 to 25,000 volts.

TRADE CATALOGUES.

Allis-Chalmers Co., Folder No. 4002, offers in a very neat and concise manner the advantages of the Allis-Chalmers direct current motors and generators, Type K.

Gould Storage Battery Co.—"Gould Telephone Batteries" is the subject of a most attractive little catalogue which this company has just issued. It offers the advantages of the storage batteries for all telephone work over the older style forms of gravity and other primary cells.

This company have also sent out a catalogue describing "Couple Types" for railroad signal, fire alarm and telegraph works.

Address all requests for these to their Pacific Coast sales offices, 705 Monadnock Building, San Francisco.

A SCHOOL OF RAILWAY ENGINEERING AND ADMINISTRATION.

The University of Illinois, recognizing the important commercial position that the railroads of this country fill, and the complexity of organization imposed upon all those engaged in their service, has established in the College of Engineering a new Department of Railway Engineering. Under its direction the following four courses are offered:

1. Course in Railway Civil Engineering.
2. Course in Railway Electrical Engineering.
3. Course in Railway Mechanical Engineering.
4. Course in Railway Administration.

It is planned that these courses will prepare men to perform more efficiently, through the special training obtained, the duties connected with the motive power, maintenance of way, financial, traffic and operating departments of railway service.

ANNOUNCEMENT.

The Thomas S. Clark Son Memorial School of Technology has sent out invitations for the eleventh anniversary of the granting of the charter by the University of the State of New York.

Commemorative exercises will be held on the eve of Charter Day, March Eighteenth, Nineteen Hundred and Seven. The address will be delivered by Frederick Remsin Hutton, E. M., Ph. D., Sc. D., Professor Mechanical Engineering, Columbia University and President American Society of Mechanical Engineering.

PERSONAL.

Mr. J. F. W. Bunsen has entered the employ of Muralt & Co., Engineers and Contractors, New York, and will take charge of their Southern office in Charleston, S. C.

Mr. Bunsen, who is a nephew of the late Prof. Bunsen, the inventor of the burner which bears his name, has had many years experience in designing and erecting important engineering works. At the time of the Galveston flood Mr. Bunsen was engaged as the Mechanical Superintendent of the American Cotton Co., Southern District. He was delegated by the City of Galveston to prepare the designs and plans for a system of break waters and although his plans were not immediately utilized on account of lack of funds, the present admirable break water system has been built practically in accordance with his original ideas and plans. His experience also includes the design and erection of various breweries, sugar refineries, spinning mills and electric light and power plants, including oil refineries for the Standard Oil Co. in Mexico and South America, cotton mills for the American Cotton Co. and various sugar plants in Cuba, Mexico and South America.

Mr. Bunsen will have charge of Muralt & Co.'s various projects in the Southern States, and especially the large power plant which that Company is now building for the U. S. Government at the Charleston Navy Yard.

LUMINESCENCE OF THE GAS MANTLE.

Dr. C. Killing finds that a Welsbach mantle gives, in a flame of hydrogen burning in chlorine, a blinding greenish light. The mantle was not attacked by the chlorine. Dr. Killing concludes from this that the ceria in the mantle does not act as an oxygen carrier, and that the luminescence is an effect of high temperature simply.

Long Beach, Cal.—Work on the extension of the Pacific Electric main line to West Long Beach is being pushed rapidly.

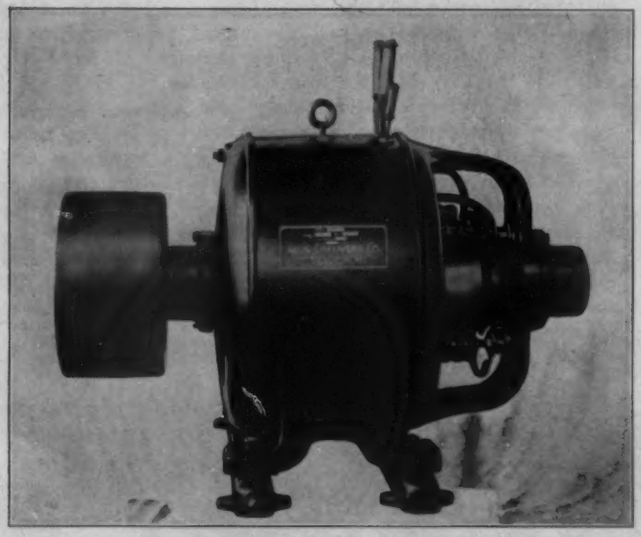
INDUSTRIAL

ALLIS-CHALMERS DIRECT CURRENT MOTORS AND GENERATORS—TYPE "K."

The growing demand for direct current electric motors that can be applied to the individual drive af machinery of various kinds has led to a number of important changes in both the mechanical and electrical design of the motors heretofore used. To meet the requirements of this service the construction should not only be compact but also permit of mounting the motor in any position; while the windings and commutator must be either partially or wholly protected from external injury. Geared and direct-coupled methods of driving are rapidly displácing belts, and this, together with the fact that sudden and excessive overloads are of common occurrence, requires larger bearings and shafts of greater stiffness than were formerly used in motors of the same class. The demand for a wide variation in speed by shunt field control, with occasional heavy overloads at any speed, has also called for material improvement in commutating qualities.

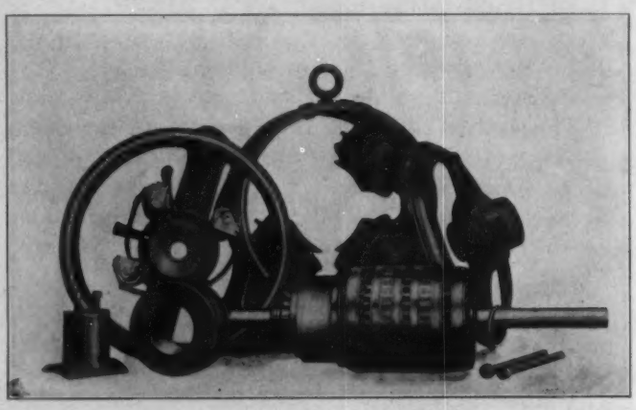
Allis-Chalmers Company, of Milwaukee, announces a new line of direct-current motors, designated as Type "K," which have been especially designed to meet these mechanical and electrical requirements. They are equally well adapted to belt drive at constant speed and continuous service, or geared drive, variable speed and intermittent service.

Their external appearance is similar to the well-known Types "N" and "B" motors heretofore manufactured by that company, but the construction differs in many important details and, in fact, represents a new design throughout. The changes, both mechanical and electrical, are the result of many years' experience in the construction of motors for industrial purposes. The machine is very compact, the construction is rigid, and every detail has been worked out with especial reference to the most exacting requirements of modern service.



ALLIS-CHALMERS TYPE "K" MOTOR.

The cylindrical field magnet yoke is of open hearth steel and machined on each end to receive the housings that carry the bearings. The housings are held in place by through bolts and, on four-pole machines, can be rotated 90 degrees or 180 degrees to allow side-wall or ceiling mounting; bi-polar machines can be arranged for floor or ceiling mounting. The yoke is machined on the inside cylindrical surface and the poles are fastened to it by counter-sunk fillister-head cap screws. The pole cores are of open hearth steel and are circular in cross section; these cores are machined on one end to fit the inner surface of the cylindrical yoke and on the other to receive the pole shoes. The latter are built up of annealed steel punchings riveted together and fastened to the poles by flat head machine screws. The pole face has been carefully shaped to give suitable distribution of the field flux, thus securing good commutation and preventing humming due to the armature teeth. The field cores are wound on metal spools, except for the smaller sizes, and are covered with sufficient insulation coated with varnish to protect them from external injury or moisture.



5-HORSEPOWER ALLIS-CHALMERS TYPE "K" MOTOR, DISMANTLED.

The armature cores are built up of sheet steel punchings insulated from each other to reduce the core loss and consequent heating. The laminations are keyed to the shaft, and in building up the core they are separated at intervals so as to form radial ventilating ducts. The punchings are firmly clamped between cast iron end heads, which also serve as supports for the ends of the armature coils. In punching the armature laminations, openings are made in the discs, so that when the latter are assembled, ventilating passages are formed parallel to the shaft and connecting with the radial ducts. There is thus a free passage for circulation of air through the core, and all parts of the core and windings are thoroughly ventilated.

The armature coils are form wound and interchangeable; they are heavily insulated with stay binding and the whole armature is thoroughly impregnated with insulating varnish after it has been completely wound.

The commutator is of large diameter and ample wearing depth, having bars of hard drawn copper insulated from each other and from the shell by the best quality of mica; the mica between bars is selected so as to give even wear. The clamping rings hold the bars very firmly, and the whole construction is such as to secure a perfect cylindrical surface free from high or low bars.

The commutator sleeve, in all except the smaller sizes, is cored to permit the passage of air through to the armature.

The shaft is made of high carbon steel, which is very stiff and can stand heavy overloads without vibration or bending.

The bearings are amply large, and lubricated by oil rings which rest on the shaft and dip into oil wells beneath. The shaft projection for the pulley is turned smaller than the journals, so that the journal can be turned down, when worn, without reducing its diameter below that of the projection.

The brush holders are of the reaction type, of the same

general design as used on all Allis-Chalmers standard direct current machines. They are simple in construction, positive in action, and allow the brush to follow the surface of the commutator freely. The brushes are held firmly to the holders and, while they can be readily removed, for inspection, it is not possible for them to get out of place while in service. The brush studs are fastened to a rocker arm mounted on the bearing housing; this allows the brushes to be set at the best running position, but, after being once properly set they require no adjustment under any change in load within the range of the motor. The brushes are graphite and are connected to the holders by flexible copper shunts so that current is not compelled to pass through any sliding contacts; ample carrying capacity is provided in the brushes and brush holders and all parts operate at low temperature.

The standard Type "K" motor is made open at the ends to permit a free circulation of air through the machine; it can, however, be made semi-enclosed or totally enclosed by the addition of suitable metal enclosing covers which are readily fitted to the end housings. For the semi-enclosed type the covers are perforated, forming a screen cover which, while allowing a circulation of air, protects the motor from flying particles; this type of motor can be used on work where an open motor would not answer but where an entirely enclosed one is unnecessary. Totally enclosed motors are dust and moisture proof, since the tightly fitting covers close up all openings. This shuts off the ventilation, and the output of a given frame for the totally enclosed type is less than for either the semi-enclosed or the open types.

In the use of variable speed motors for the individual drive of machine tools, there are two points to be carefully considered:

(1) The size and weight of the motor is dependent to a great extent on the minimum speed at which the motor is required to develop its full rated power; the slower the minimum speed the greater will be the size and weight for a given horsepower output.

(2) The maximum speed of the motor is dependent on the peripheral speed of the armature, commutator, pinion, or belt; or upon the ratio of speed reduction between the driven shaft and the motor shaft. This limits the maximum speed to 1,000 to 1,600 revolutions per minute, depending on the output of the motor. The maximum speed being thus fixed by mechanical limitations, any increase in the range of speed variation must be obtained by decreasing the minimum speed and consequently increasing the size of motor for a given output, or decreasing the output for a given size. These mechanical limitations make it desirable to keep the speed range down to a reasonable amount and it has, therefore, in Type "K" motors been limited to a ratio of 1:3.

These motors are manufactured in 13 different frame sizes, and for each size there are a number of ratings, the output of a given frame being proportional to the speed.

Type "K" motors are suitable for all classes of work where either a constant or variable speed direct current motor is required. For general driving of machinery or for variable speed work shunt wound machines are used. For cases where a large starting torque combined with the constant speed characteristic of the shunt motor is required, compound wound motors can be furnished. For crane and hoisting service series wound motors are supplied.

Type "K" machines operate exceptionally well as generators which are compound wound, and will deliver any current from zero to their full rated output without sparking and without shifting the brushes.

Type "K" machines are given the same high grade finish that characterizes all Allis-Chalmers electrical apparatus. All castings are filled and rubbed down to a smooth surface. The workmanship is first class throughout and all motors are thoroughly tested before being shipped.

Lewiston, Ida.—The Northwestern Railway has begun work on a line between here and Huntington.

MODERN SWITCHBOARD DEVICES.*

C. W. Stone.

The oil switches of today are very necessary in high-tension systems for the distribution of energy, and to them is to be attributed the successful operation of such systems. The opening of an arc in the air on an alternating-current system is apt to result in dangerous rises in voltage, by causing surges in the system. Indications tend to show that an oil switch opens on the low point of the wave, or practically at zero current, and for this reason it has a tremendous advantage over any switch opening in the air.

A switch, which may be considered as an example of present oil switches for moderate capacities, has the operating mechanism and the contacts and the contact rods, etc., located on a top casting. The contact rods which pass through the casting are surrounded by porcelain insulators. These contacts are enclosed in an outside tank, which is filled with oil, barriers being placed between the different poles. Contact yokes are carried on the end of wooden rods, which are attached to the operating mechanism. The movement of the handle raises or lowers the yokes, bringing them when raised into connection with the contact blocks.

For very large loads a totally different design of switch is used. Each pole of this switch is made up of two cylindrical oil vessels, the bottom of which contains a contact. The oil vessels are mounted on large insulators placed in the base of a switch compartment. The two elements of each phase are separated from the other phases by means of brick or soapstone barriers. Passing through the top of the two oil vessels of each phase are two contact rods which are placed on a yoke. The yoke is fastened to the operating mechanism by means of a long wooden rod. The connections to and from the switch are made to studs passing through the insulators which support the oil vessels. The operation of this switch is exactly opposite to the one described above, as in this case the contact rods are pulled up from the contacts, while in the other type of switch the contact rods are dropped away from the contacts. The operating mechanism may be driven by compressed air or electricity. With the electrically-operated switch, the tripping is entirely independent of the motor, as the action of the switch is such that the motor carries the crank of the mechanism slightly past the center, where it is held in position by a small toggle which is opened by means of a small electro-magnet. Many improvements have been made in the small details of this type of switch since it has been in use. One of the latest and best improvements is in making the oil vessels of pressed steel. The original vessel was made of seamless brass pipe. In the lower end of this pipe a bottom carrying the contact was soldered, and the top was threaded to receive the cap. The new type of vessel is made of steel, the top being put on in the same way as on the brass pipe.

Oil switches of the type just described are in successful use for e.m.f.s as high as 60,000 volts. In the 60,000-volt switches, the oil pots instead of being of metal are made of wooden staves somewhat like a barrel, held together by wrappings of cord. The pots are mounted on insulating standards.

For alternating-current work a number of different types of relays are in use; the overload relay which has been generally used consisting of a simple solenoid and a set of contacts, so arranged that the movement of the plunger in the solenoid will properly operate certain contact mechanisms. The relays are made both for instantaneous operation and with time-limit arrangements. An excellent type of time-limit arrangement consists of a simple bellows placed above the contacts and fastened to the plunger. This bellows is provided with a small valve at the top, the open-

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*Abstract of paper read before the New York Electrical Society.

ing of which can be adjusted so that the relay can be set for any desired time. With a relay of this type the time element is dependent upon the amount of current flowing through the solenoid, and is practically directly proportional to this current. Thus, if set for a certain time with a certain current, if the current is double, the relay will open in practically half the time, and in cases of short-circuit, it becomes practically instantaneous.

Another type of time-limit relay is the definite type which is made in two ways. One is the bellows type, which is very similar to the inverse time element type, the only difference being that the plunger is not rigidly connected to the bellows, but has a spring interposed in such a manner as to make the pressure on the bellows constant whenever the relay operates. The other form is a clock-work mechanism, which revolves a fan, the blades of which can be adjusted so as to require a pre-determined time of operation.

SINGLE-PHASE GENERATOR AT BELLEVILLE, ILL., WORKS ECONOMY IN FEED WIRE COPPER.

Belleville, Ill., having some 20,000 inhabitants, possesses a greater number of manufacturing industries of various kinds, especially foundries, than is usual for a town of its population. The Belleville Gas & Electric Company, which has been supplying both light and power for these factories for several years, for a long time maintained a 500-volt, direct-current service which, it was found, required considerable expenditure for feed wire copper in order to extend and enlarge its service to take care of new factories scatterd along the rights-of-way of several railroads passing through Belleville.

A means of overcoming this difficulty was presented in the alternative of supplying power from single-phase lighting circuits or of installing a polyphase distributing system for power purposes. The latter plan involved expensive changes, so that the use of a single-phase system was adopted and a Corliss engine direct connected to a single-phase generator was the equipment selected to solve the difficulty. The generator is a 550-kilowatt, 2,300-volt, 60-cycle machine of standard Allis-Chalmers design, and the engine is one of the well-known Reynolds Corliss type, 30-inch by 48-inch, also built by that company.

While a considerable portion of the present output is through a 500-volt, direct-current generator, the 500-volt system is not being extended. All new business is taken on the single-phase alternating-current circuits, and some business has even been changed from 500 volts direct-current to single-phase, alternating-current, because of better voltage regulation on the alternating-current circuits. Out of a connected load of about 900-horsepower, 500 is in direct-current motors.

THE ELECTRIC STORAGE BATTERY CO., GENERAL OFFICES PHILADELPHIA, PA.

Announces the removal, on April 22nd, 1907, of its Pacific Coast sales office from No. 525 Thirteenth Street, Oakland, to temporary quarters at No. 11 Hawthorne Street, San Francisco. Later, notice will appear of its removal into permanent quarters now being prepared in the Crocker Building.

The operating department will be permanently located, after April 1st, 1907, at No. 11 Hawthorne Street, San Francisco.

The Pacific Coast stock of "Exide" and "Chloride" batteries will be handled by, and may be purchased of the "Exide Battery Depots, Inc.," which will be permanently located at No. 11 Hawthorne Street after April 1st, 1907. R. B. Daggett, manager San Francisco office.

BAY SHORE ELECTRICAL CONSTRUCTION COMPANY REMOVED TO NEW QUARTERS.

We wish to announce that we have removed our shop to more spacious quarters at No. 40 Tehama Street, San Francisco, where we are equipped to handle all classes of electrical and machine repairs, and still have our armature and switchboard departments at the disposal of our friends.

ELECTRIC WIRING RULES IN TORONTO.

The leading electrical firms in Toronto have adopted a new code of rules bearing on electric wiring with a view to better standardization and reducing fire risks. These rules are embodied in a bulletin (No. 8) issued by the electrical department of the Canadian Fire Underwriters' Association, and are designed to meet not only modern requirements but to prepare for what seems inevitable in Toronto—namely, the increasing of the lighting voltage from what it is at present to 240-480-volt three-wire system. The committee state that in anticipation of this increase in voltage, they desire to see adopted "new code standard cut-outs equipped with approved enclosed fuses. This will mean, so far as the city of Toronto is concerned, the complete discarding of all other styles of fuses. In factory work and other places where drop lights are to be used, the use of fused rosettes is to be entirely abandoned. Generally speaking, the observance of the separation of wiring in concealed work will have to be more carefully regarded, and while we will not expect the full 10-inch between wires of opposite polarity, we will expect that the wiring in such places will be more spread than it is at present, and that the running of wires underneath bath-rooms, where they are liable to come in close proximity to water-pipes, be carefully avoided." The foregoing requirements are asked for immediately. The use of nails in connection with insulators is also to be discontinued, and the bulletin states that the committee expect that they will be securely fastened with screws. The use of ordinary weather-proof wire is prohibited, and for all inside work, slow-burning weather-proof wire is to be used, except in damp places, in which locations improved rubber-covered wire may be used. Aerial service wires in pipe or otherwise must not be concealed in walls or partitions before entering cut-out and switch. All branch circuits of two wires from center of distribution to lamps should consist of a black and a white core wire, being colors easily distinguished, the black wire being merely maintained as the neutral or grounding wire and the white for the positive, so that the mistake of placing the single-pole switch on the black wire may be avoided. In bath-rooms, cellars, or any place where it is liable to be damp, or where a person is liable to stand and touch wires, outlets should be on the ceiling. All electrical contractors should endeavor to keep the receptacles, sockets, and fixtures throughout an installation polarized, so that the black or neutral wire shall be always on the shell side of the socket or lamp. Parties installing electric fixtures are strongly advised to have them thoroughly inspected, and contractors are urged and requested to pay particular attention to the making and finishing of joints under canopies. Special rules have also been formed for other general electric work.

San Jose, Cal.—Within fifteen days the Santa Clara street line, from First Street out to the Alameda, will be in operation on one track, and in thirty days, it is estimated, both tracks will be ready for public service. The work, which commenced a few days ago, of broadening the gauge of the tracks has been going on rapidly, and an extra gang of workmen has been put to work to expedite matters. One of the finest road beds in the West is being prepared, and when the track is finally ready for the public it is expected by the company that the highest class of street railroading will be given.

NEWS NOTES

ELECTRIC RAILWAYS.

Lind, Wash.—R. Roberts has taken the contract for three and a half miles of the Milwaukee grade from the crossing of the N. P. east.

Bellingham, Wash.—It has been reported that the Bellingham Bay & British Columbia Railway has been acquired by the Northwestern Portland Cement Co.

New Westminster, B. C.—Construction work on the V. V. & E. between Cloverdale and Abbotsford will commence shortly.

Seattle, Wash.—The C., M. & St. P. Railway has filed an application for a permit to lay two and a half miles of track in the city at once.

North Yakima, Wash.—Actual construction on the mountain division and Yakima section of the C. M. & St. P. Railway from the Columbia River to Seattle will commence April 1st.

Elma, Wash.—The N. P. Railway Co. will begin work on surveying the probable new line of railway that is to encircle the Olympia Peninsula, at once.

Lakeview, Ore.—E. H. Harriman has bought the Corvallis & Eastern Ry., running from Yakima Bay to Idanha, a distance of 142 miles.

Bellingham, Wash.—It is reported that the N. P. Railway will build a brick and stone depot here, and also a mile more of sidetrack, making an expenditure of between $40,000 and $50,000.

Northwestern Gas and Electric Company—Isaac W. Anderson, president, and A. Welsh, manager, who have just completed a tour of inspection over the system, announced in Spokane that trains will be operated between Walla Walla and Freewater and Milton in less than sixty days

Spokane Northern Electric Railway Company—Francis D. Cook, one of the original projectors of the system to operate between Spokane and Dartford, announces the line will not be built this year. The land deeded to the company by Mr. Cook has been turned back to him, and the company will be reorganized.

Tekoa-Saint Maries River Railroad Company—These officers have been elected for the year: President, F. J. Mahoney; vice president, E. C. Dowel; secretary, M. D. O'Connell; treasurer, Dr. W. A. Mosier; also a directorate of fifteen members. The line will extend from Tekoa, Wash., south of Spokane, to Indian Creek, and will be in operation, it is given out, in time to move the season's crop. Electricity will be the motive power, and street cars will be operated in Tekoa. The line will be ultimately extended to the timber belts of the St. Maries River in Idaho.

Lewiston & Southeastern Railway Company—G. W. Thompson, a stockholder, announced in Spokane that the Schofield Company, of Philadelphia, will build the system, which, together with the power house on Salmon River, will cost $5,200,000. He added that construction work will begin the coming summer on the Lewiston and south of Spokane, continuing toward Waha and Grangeville. The work will require two years. It is given out that the bond issue covering the cost of the system has been disposed of to eastern investors.

Spokane & Inland Electric Railway System—Announcement is made that the company will build 200 miles of line south of Spokane during the coming year. The main line from Spokane to Colfax, 80 miles, and branch lines to Moscow and Lewiston are included in this. Projected lines run from near Colfax to Snake River to connect with the line from Walla Walla north through Dayton.

Okanogan Electric Railway—Reports from Riverside, Wash., are that the electric road, projected by A. M. Dewey, of Spokane, which was to be built from Nighthawk to Brewster, Wash., has changed its route, and is being surveyed from Nighthawk via Loomis, Fish Lake, Johnson Creek Valley, across the government's Okanogan irrigation project to the new town of Omak, on the Okanogan River, across the latter, through Omak Pass on the south half of the Colville Reserve to the mouth of the Spokane River, thence on to a terminus in Spokane. This leads to the expressed belief that the road is a branch of the Graves system. Mr. Dewey is in New York on business in connection with the project.

FINANCIAL.

Sacramento, Cal.—Gov. Gillett has approved the Willis bill legalizing certain municipal issues of bonds which will enable Los Angeles to issue $23,000,000 for a new water system. It is expected that action will be taken on the issue at once.

San Diego, Cal.—An election has been called in this city on March 12 to vote on an issue of bonds amounting to $884,533.71. The money is to be spent to construct and acquire a line of water pipe; for the enlargement and extension of the water system; for reservoirs, boulevards, reinforced concrete culverts; for construction of a building and repair of other buildings for the fire department; for a park, extension of sewer systems and for three public lavatories.

Fresno, Cal.—One day before the option was to have expired, the properties of the Oil City Petroleum and the Twenty-eight Oil Companies, in the Coalinga field, passed into the hands of parties represented by W. M. Hall, of San Francisco, for the sum of $855,000. But the hand behind the purchase is that of the Standard Oil Co. The transaction is the largest ever consummated in Fresno County. There are 280 acres in the lease of the Oil City, and 160 in the Twenty-eight. The combined wells are recognized to be among the best producers in the State. Outstanding moneys will be called in and the two companies will be liquidated. The transaction is not a shift in the control of stock, but a complete purchase. For some time the product of both companies has been sold under contract to the Standard Oil. But when the contracts expired no new ones were drawn up and operations at the wells were practically suspended. Under ordinary circumstances the twenty-five shafts produced each month about 50,000 barrels of high-grade oil. A short time ago the Standard Oil Co. purchased eight acres of oil lands belonging to the Oyama Oil Co. and the Forty Co. The purchase price was $350,000. This, added to the recent deal with the Twenty-eight and Oil City concerns, makes a total transaction of $1,205,000. Not long previously a $2,000,000 deal, to be paid in installments by the Standard, was brought to a head.

San Francisco, Cal.—An immediate seizure of the properties of the Spring Valley Water Co. has been advised by City Attorney Burke in a communication to the Board of

Supervisors. He and his assistant, Wm. S. Baggett, have fortified themselves with many legal authorities to support the proposed action of the city, and declare that the Supreme Court of California has so passed upon the issues involved that there can be no question of the right of the city to proceed at once to drastic action. Attorney Burke says: "No further legal action is necessary to enforce the forfeiture. It need not be established judicially. The forfeiture is declared by statute, and when so declared the title goes with it. The title immediately vests in the State upon the happening of the event or the commission of the offense for which the forfeit is declared. This is the settled law of the State." Attorney Kellogg of the company declares that the Federal Constitution would prevent the seizure of the water works, as article 14 states that private property shall not be taken for public use without just compensation. He says that the whole matter will have to be threshed out in court, as the supervisors will have to prove their accusation, and that until this is done their action in declaring the property of the company confiscated and forfeited has no legal force. Capt. A. H. Payson, the president of the corporation, says that the city will have to pay for the water works if it wants them, and sets the price at $50,000,000. He says: "We are quite willing to sell our plant, but we shall not submit to any act of piracy on the part of the supervisors or any other city officials." City Attorney Burke takes the ground that the plant of the Spring Valley Company is not private property, and that therefore the Federal Constitution does not apply to the case. Secretary Duke, of the company, states that he will cut off the supply outside of the town if the proposed action is taken, and the city will get nothing except a series of empty pipes.

OIL.

Los Angeles, Cal.—The Bowser Oil Tank Co. has written to the president of the Chamber of Commerce in regard to securing a site on the inner harbor.

Santa Monica, Cal.—The Santa Monica Oil and Gas Co. has been organized to drill a well about ten miles northeast of the town. Thaddeus Brewster has been made president of the new company. Several Los Angeles men are interested in the project.

San Luis Obispo.—In a letter to the "Pacific Mining and Oil Reporter," L. E. Blochman writes: "Along the water front, about six miles from the Tiber, Oil Port is looming up on San Luis Bay. The substantiality of the buildings can be seen by the manner in which the foundations are laid. The California Petroleum Refineries Co., Ltd., is doing the most far-reaching things possible, following generally the lines of the Union Oil Co., except that it is having its refinery plant connected by pipe line from the Graciosa property at Santa Maria. Both the Union and the Standard must transport their oil by ships to a distant refining point, a delay and an expense that the California Petroleum Refinery overcomes.

San Francisco, Cal.—In February the cargo shipments of refined petroleum to foreign countries from the local customs district were as follows:

To	Gallons.	Values.
Madras, India	2,394,000	$ 93,366
Hiogo, Japan	931,000	69,840
Shanghai	1,600,000	62,400
Total refined	4,925,000	$225,606
Crude Oil, Honolulu	630,000	9,000
Grand Total	5,555,000	$234,606

The cargo of refined for Hiogo was in cases, and the balance was in bulk. In January the shipments were very large, being 7,412,002 gallons, and all refined.

The Union already has found it very profitable to have a smaller refinery near Port Harford Wharf to take off the top oil for such fuel oil where the law exacts a high-flash test.

PRODUCTION OF OIL FOR 1906.

Estimates of United States production and consumption of oil for the past year, designated in barrels, are in round numbers as follows:

Fields.	Production.	Consumption.
California	26,000,000	32,000,000
Pennsylvania	25,000,000	27,000,000
Ohio and Indiana (Lima oil)	24,000,000	28,000,000
Kansas, Ind. Territory and Oklahoma	22,000,000	13,000,000
Texas and Louisiana	21,000,000	29,000,000
Illinois	3,000,000	1,500,000
Kentucky and Tennessee	1,200,000	1,000,000
Other States	1,000,000	1,000,000
Totals	123,200,000	132,500,000

For the purpose of comparison the government's report by States of production in 1905 is reproduced as follows, the designation being in barrels: California, 33,427,473; Texas, 28,136,189; Ohio, 16,346,660; Kansas, Indian Territory and Oklahoma, 12,013,495; West Virginia, 11,578,110; Indiana, 10,964,247; Pennsylvania, 10,437,195; Louisiana, 8,910,416; Kentucky and Tennessee, 1,217,337; New York, 1,117,582; Colorado. 376,238; Illinois, 181,084; Wyoming, 8,454; Missouri and Michigan, 3,100. This summary includes with Ohio's production, 5,016,736 barrels produced in Southeastern Ohio, which was of the Pennsylvania grade, and which, added to the New York, Pennsylvania and West Virginia production, made the production of crude of the Pennsylvania classification 28,149,623 barrels for the year 1905.

TRANSMISSION.

Stockton, Cal.—The American River Power Co. purchased recently from the Weber Home Co. lots 2, 4, 6, 8, 12 and 14 in block 23 west of Center Street, and located on Lindsay Street between Madison and Monroe Streets. The power company will establish a sub-station in Stockton to supply light and power and to act in all respects as an auxiliary to the main plant.

Los Angeles, Cal.—The city has advertised for bids for furnishing the necessary hydraulic and electrical machinery, apparatus and line material for equipping one hydro-electric generator plant of 125-kilowatt capacity, five miles of 15,000-volt transmission line, and step-up and step-down transformers. The apparatus must comply with plans and specifications now on file in the office of the Board of Public Works.

Anderson, Cal.—A large water-storage dam is to be built at the lower end of the McComber flat, on upper Battle Creek, in the Shingletown country, by the Northern California Power Co. The water will cover an area of 500 acres in its confinement. The object of the company is to have a reserve supply on hand when Battle Creek at this point becomes low during the latter part of the summer, and cannot supply sufficient water for the use of the electric generating plant at Volta. This dam has no association with the one they are contemplating building on Battle Creek for the new 12,000-horsepower generating plant.

Fresno, Cal.—A scheme for furnishing light and power to Death Valley, in California, and in and about Bullfrog, in Nevada, was revealed last week by the filing of claims in the recorder's office for water rights. The parties interested are R. W. Thomas, Wm. Snyder, H. E. Woodward and F. S. McKee. Power plants are to be established at various points on King's River, an immense amount of power being obtainable from the numerous tributaries. The mines of Southeastern California have long lacked both water and power for developing purposes.